# HAND GESTURES AS COMMUNICATION FACILITATORS IN DESIGN:

## A research based design study to understand the role of hand gestures during group design communication

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**HAND GESTURES AS COMMUNICATION FACILITATORS IN DESIGN:**

**A research based design study to understand the role of hand gestures during group design communication**

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**SUMMARY**

The design discipline is reliant on communication as a means to express and share ideas during the creation of products. Design communication can take place in two distinct settings: formal communication presentations and informal interaction communications, both being performed in a group. Formal communication involves one speaker presenting his/her ideas to an audience where the delivery of content is unidirectional (i.e. a single presenter to audience relationship). Informal communication is multi-directional and involves interaction among two or more individuals (i.e. multiple presenters relationship). Group design communication involves the communication of various attributes of a design. Designers employ various mechanisms including verbal, non-verbal (e.g. hand gestures), and physical tools (e.g. sketches and models) to communicate attributes. Physical tools can be too static, where a sketch attempts to explain a 3D object in 2D, and verbal communication is limited to the speaker's oratory skills. Although the verbal and physical tools are effectively used, hand gestures remain underused. Yet, hand gestures are extensions of the human mind, which may reveal thoughts that verbal communication may not be able to communicate (McNeil, 1992). Hand gestures have the potential to reveal thoughts that cannot be communicated during design communication through verbal or physical tools and if used as an interface mechanism, can augment the information space. As such, hand gestures may facilitate design communication within a group. This is of importance since it is evident that communication between designers is co-creative in nature. This study explores the potential of hand gestures as tools in design communication. Moreover, the

purpose of this study is to understand how gestures can facilitate the design communication that occurs within a group. A two-phase study was proposed: a research phase and a design phase. During the research phase, ethnographic research in design education environments was conducted to understand what gestures are produced and how they are used during formal and informal design communication settings. The data collected was analyzed and categorized to reveal quantitative and qualitative results. Survey studies were also conducted to validate hand gesture meanings. The data was used to create design guidelines that directed the design phase, where concepts used hand gestures as interface mechanisms to augment the experience of a design information exchange. The significance of this project is to generate new knowledge to be applied to the development of more natural technological systems where gestures are used as an alternative to current input devices (e.g. mouse and keyboard) for navigation and manipulation of design material among a group. The goal was to improve the communication between designers and their materials, using design and technology and to enhance the experience of distributing and receiving design information.

## CHAPTER 1

## PROLOGUE

The design of products directly impacts the lives of people who use them. The increased inclusion of technology into a plethora of everyday products has the potential to either make the experiences of using them more satisfactory or unnecessarily complex. My interest, as a designer, focuses on the need of integrating design and technology in products, with the goal of improving human experiences (Fig.1). One such area of experience is human communication.

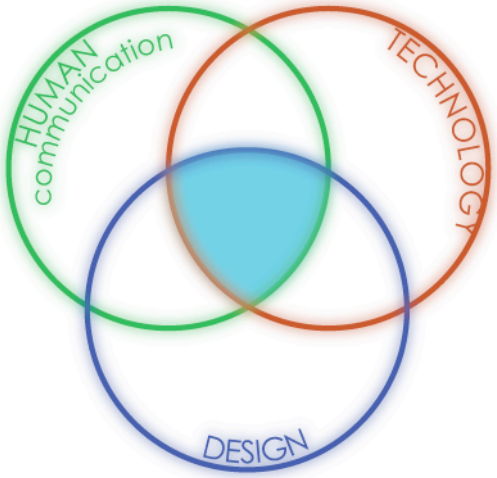



*Figure 1: The intersection of the designer's interest*

A product should have the ability to improve communication, via efficiency and satisfaction of use. As technology encompasses the lives of humans, the paradigm where humans adapt to products unnaturally needs to shift to where

human-product interaction occurs naturally. A natural interaction is considered better than a learned or unnaturally mediated interaction. The rationale for this is simply that in a natural interaction a human does not need to learn, or change, to use a product. The change occurs on the product end rather than the human end of the interaction. As the interaction is not always successful when attempted to be natural, it is the responsibility of the designer to understand how users interact with and use products in order to create products that are best adapted to working as naturally as possible with humans.

The rationale of natural interactions needs to be applied towards human communication mediated by technology. As the impact of technology increases in human's lives, the manner with which and the amount of communication that occurs will change. As this change is occurring, designers have the opportunity to recommend and implement new methods of human communication by exploring new paradigms for human-product interaction.

# CHAPTER 2

## INTRODUCTION

Industrial design is the practice of developing products and services. This development occurs iteratively, in phases, depending on the complexity of the project. The phases may include a research phase, concept generation, concept refinement and final concept. Each of these phases requires communication between individuals and groups. As such, the industrial design discipline can be characterized within a co-creative process involving a group to bring about ideas.

During design communication, various methods and tools are used for the creation of products and services. The communication can occur verbally, non-verbally, and physically in the form of design material such as sketches, physical models and 3D models. The information being communicated between designers is vital and shared to explore various attributes of a product. Some of the main attributes of a product being communicated are its form, function and usability. Physical tools can be too static, where a sketch attempts to explain a 3D object in 2D; and verbal communication is limited to the speaker's oratory skills. Although the verbal and physical tools are commonly used effective tools, designers tend to use their hands to effectively gesture product attributes.

Hand Gestures, are the "movements of the hands and arms that we see when people" communicate (McNeil, 1992). They refer to, for example, the upward motion hands make during the story telling of how a boy climbed a tree. They are

part of a plethora of communicative tools referred to as 'nonverbal communication" (Goldin-Meadow, 2005) Hand gestures are commonly used to express various aspects of a design (scale, placement, form etc.), and "exhibit images that cannot always be expressed in speech, as well as images the speaker thinks are concealed" (McNeil, 1992). The authors suggest that gestures are deeply connected to thought thus augmenting communication. (McNeil 1992, Goldin-Meadow 2005). The integration of gestures in the design process can have the potential to make the communication more effective.

Hand gestures, such as pointing and selecting objects with the index finger, are a commonly used input medium with new interactive technological products such as the Microsoft Surface and various Apple products (e.g. iPhone, MacBook Pro), which suggests that they are becoming more accepted as part of the relationship between users and their products. Hand gestures are currently used as input medium, relying mostly on fingers (single and double) for selection and zooming purposes. They are natural and simple mechanisms for interacting with technology. However, hand gestures have the potential to play a major role as an input device, especially for communication.

Literature suggests that as technology becomes a more important part of our lives, harnessing its potential for the purpose of smoother communication becomes increasingly relevant. Mark Weiser (1991) prefers technology weaving "into the fabric of everyday life until they are indistinguishable from it." John Maeda (2007) suggests how it is becoming increasingly necessary to embrace

simplicity into our products. Designers are already using technological tools in one form or other for communication (e.g. PowerPoint, Projectors, Modeling software etc.). While hand gestures may be considered a useful communication input medium, it is important that their use is appropriately 'mapped' (Norman,1994) to the functions that are relevant to the design process. Following the writings of Weiser and Maeda, the design community could benefit from a simpler relationship between technological products and their communicative material.

This study explores issues of how designers currently use gestures, and how they may become part of an interface mechanism. The purpose of the study is to understand how gestures can facilitate the design communication that occurs among a group. The study addresses what gestures are used within the design communication context, and how the identified gestures along with technology can augment design communication among group. Specifically, this is accomplished by proposing two phases: a research phase and a design phase. The research phase involves conducting ethnographic research and validation experiments. With this information, a design for an interface, which applies a gesture-based system to improve design tasks, was conceptualized. As such, in the design phase, data collected from the previous phase directed design guidelines for concept generation.

The ethnographic studies observed eight designers presenting concepts through various mediums (example: sketches, images, Flash). The metrics included a clear understanding of how gestures were used, how people gesture, what attributes

users were trying to communicate through gestures and how can the communication be improved. Within this context, the period at which designers communicate with one another in informal or formal settings was focused upon. Formal communication involved one speaker presenting their ideas to an audience where the delivery of content is unidirectional, i.e., a single presenter to audience relationship. In contrast to the formal communication presentations, informal interaction communication was multi-directional, i.e., an iterative multiple presenters relationship. In this type of communication, two of the individuals formed a group and presented their concepts to each other. In other words, individuals acted as both an instructor as well as an audience.

As communication occurs at all points in the creation process, the studies involved a controlled environment where the number of independent variables was limited. This environment was a design classroom where students presented material to each other as well as an instructor. The results attained during this phase of the project were analyzed and then used for validation purposes through surveys. The use of gestures and their meanings were extracted and then tested in the second phase to note if the analysis was correct. Both these phases dictated the design decisions that were made in the design phase of this project. The end result of this design study was the incorporation of gestures into a solution that augments the experience of communication between designers.

In summary, it was imperative to understand what gestures are used in their natural environment in order to associate different gestures with their specific

meanings and to translate them into a simple and effective interface that doesn't require highly mediated steps. The study was conducted in different phases each addressing a different research question.

**Specific Aims**

Specifically, this project will:

**1. Identify what gestures are produced during group design communication**

The goal is to identify what gestures are produced, focusing on the actions of the hands, the frequency with which they occur and how ubiquitous they are between various research participants. The gestures will be noted in their natural setting, i.e. a design presentation. This identification will also explain what attribute was the gesture communicating.

**2. Identify the differences in design communication between formal and informal presentation settings**

To incorporate a system of gestures, it is relevant to understand how design communication (if it does) differs from formal to informal presentation settings.

**3. Develop gesture and technology based tools for group design communication.**

The design solutions developed for this project will be supported by the observational studies and analysis from previous phases in study. Various concepts will be iterated upon and directed by an established set of design guidelines.

**Significance of study**

Two main outcomes were expected from this study. The first was the creation of taxonomy of gesture usage in the specific domain of design education collected via ethnographic observations during design classes, and specifically group presentation. This analysis would benefit future designers in knowing how gestures are used, and for what purpose, during design communication. In addition to providing data relevant to gesture studies, the findings will also provide a view on how designers communicate. Second, based on the analysis of gesture usage a solution that incorporates gestures, as a primary interface component will be developed to create a more natural environment between users and technology, for the purpose of improving design communication. The implementation of such a system can have positive effects on the manner in which designers collaborate, save time and improve efficiency. Gestures are expected to augment the information space often considered static or docile (e.g. Sketches, 3D model) and can enhance the experience by manipulating the space in real time.

As such, the significance of this study is to create a knowledge base where gestures have the potential to augment design communication. The knowledge will also assist in the development of more natural technological systems where gestures are used as an alternative to current input devices (e.g. mouse and keyboard) for navigation, manipulation and feedback of design content.

The design discipline is one domain where this study would be beneficial, but it has implications in other domains as well. Any domain that requires the sharing and

presenting of ideas within a group can benefit from this study. Domains such as Marketing and Advertising, Engineering, Product Development, Education etc. where people are required to discuss and develop ideas through collaboration might be assisted by this system. A further study into how gestures are used within these other domains may be required as the gestures may be specific to the domain they are being performed in.

## CHAPTER 3

## DEFINITION OF TERMS

**Design**: The Industrial Designers Society of America defines industrial design as the "professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer" (IDSA,2004). As such, it can be said that industrial design is the process by which a physical and/or digital product is created by designers. For the purpose of this study and consistency with the profession, design is synonymously used for industrial/product design, referring to the conceptualization of products.

**Technology:** Technology is defined as the overarching field where technological products are part of a task oriented system. The system may include hardware and software that is required to perform tasks.

**Human:** Human is referred as the user that is involved in communication by using verbal and nonverbal methods. The human interacts with technological products through an interface. In this study, user and human are used interchangeably.

**Communication**: Communication is defined as the interaction between one or more users that includes verbal and nonverbal (e.g. gestures) methods, where the goal is to convey the individual's ideas and concepts. In this study, the term

communication is used to address the information exchange between two or more users.

**Gestures/ Hand Gestures**: Gestures can be generally designed as the non-verbal component of a communication that occurs with the purpose of communication (McNeil ,1992). For the purpose of this project, gestures studies are limited to those conducted by the movement of hands. Hand gestures can be generally classified in two ways: spontaneous occurring without cognitive mediation by the user, and non-spontaneous occurring through cognitive mediation. In this study the concept of gestures and hand gestures are used interchangeably, focusing on both spontaneous and non-spontaneous.

**Design Material:** The visual representation of a concept. The material could range from a sketch to a physical model to a 3D model. The study explores how the design material can be augmented using gestures and technology.

**Simplicity**: Maeda (2007) defines simplicity as the state where user mediation in an interaction is improved by reducing the number of tasks, making the tasks more natural and reducing the involvement of the user, without compromising on performance. Simplicity is a guiding concept for designing products in this study and it is expected that gesture incorporation into a product.

**Interface**: As defined by Donald Norman (1995), an interface is the medium between a human and a product. There are two main stages of an interface; the

execution (input) and evaluation (output). This study exercises Norman's stages in the development of interfaces and addresses how gestures can be incorporated into the execution stage of an interface.

**Technological Devices**: Technological devices are defined as products that undergo user manipulation of a digital and/or physical interface to perform a task. The group includes products that require a level of computing, electrical energy and provide the user with multiple choices via an interface.

**Navigation**: The movement of a design material through a space, digital or physical that illustrates the moving parts of a concept.

**Manipulation**: Changing one or more attributes of the design (e.g., scale or proportions) concept to alter the design material with the intention of showing attributes changing in the idea, by scaling, shaping, turning etc. that attribute.

**Prop**: A physical object that it is placed on or in a user's hands is defined as a prop, aiding in the recognition, and feedback of a gesture.

# CHAPTER 4

## LITERATURE REVIEW

The literature review informed this project thesis in areas of technology, human communication and in design communication and practices, as this research study occurs at the intersection of these three areas. It also provided a critical perspective for this study, by establishing a 'gap' where research and studies was lacking information.

To support the focus of this thesis as the intersection between humans, technology and design, the literature is organized by these three constructs. The analysis by group was important to understand each group individually and the contribution of the group to the overall understanding of the interface between the groups. Yet, the three groups were not always mutually exclusive, and often the sources overlapped into either two or all three groups. For the sake of organizing the information and avoiding repetition, the sources are categorized under their primary group. An overall literature review map highlighting the three main sections and their sub categories is displayed below (Figure 2).Although this literature review places a source under one category, it is undeniable that many of these resources overlapped into other groups. (e.g. Pattie Maes and Pranav Mistrys project (2009) focused on the human, technology as well as design).

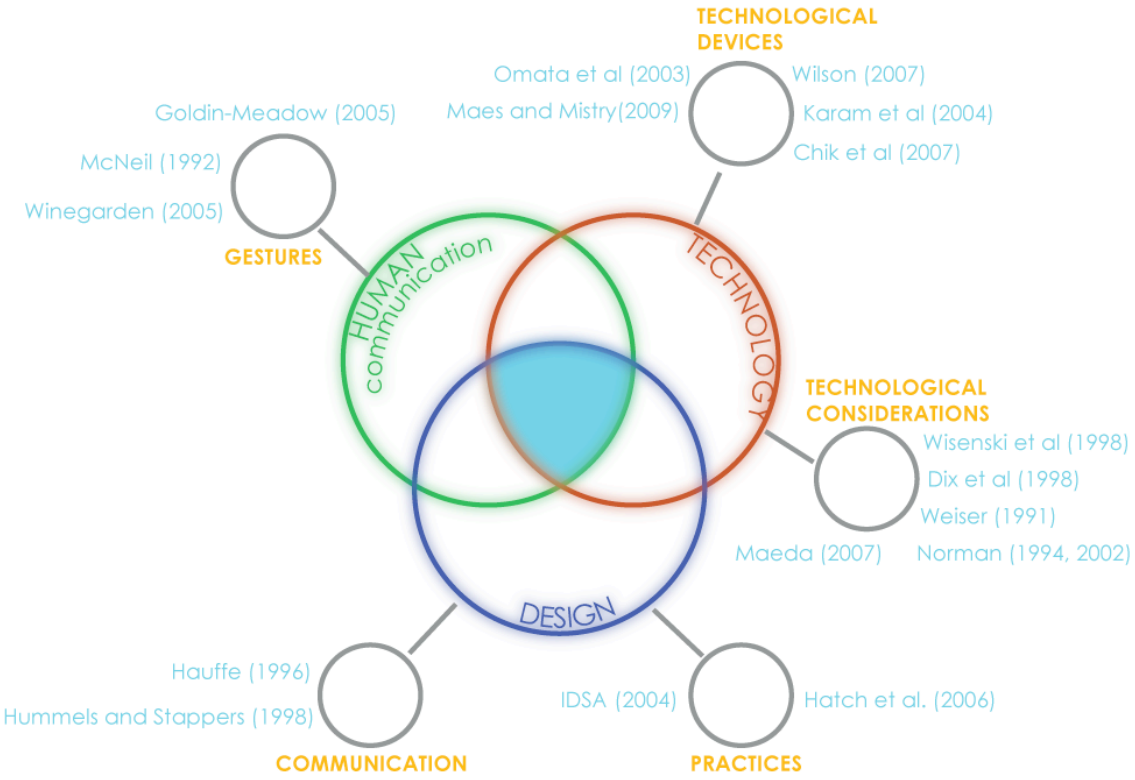



*Figure 2: Literature Review Map*

**Human Communication**

The work of Winegarden (2005) set the basis for this study, as she too was interested in how hand gestures can be used for the purpose of design communication within a group. Her study focused on understanding the role of nonverbal information in communication, proposing meaning-making tools to facilitate communication and comprehension in a group. Her study focused on understanding how gestures (specifically spontaneously occurring gestures) could facilitate communication at a distance, whereas this study attempts to understand how gestures can be used when users are located in a close proximity environment. The two projects do have quite a few similarities as they both rely on technology facilitating the use of gestures in an environment and both recognize

that gestures can become a powerful interfacing tool. One of the main takeaways from her study was in realizing the importance of gesture and communication categorization.

Communication amongst humans occurs by the means of two components. In "the traditional view of communication" there exists "…verbal and non-verbal components" (Goldin-Meadow, 2005). Verbal communication is self-explanatory and occurs by a user speaking. Non-verbal communication is the communication that occurs without speech.

An example of non-verbal communication is hand gestures, which is, the information imparted through the movements and positions of hands. The communication that occurs via gestures was understood by the writings of David McNeil (1992) and Susan Goldin-Meadow (2005), both experts in the fields of gestures and what those gestures reveal during interpersonal and intrapersonal communication. Interpersonal communication occurs between individuals, while intrapersonal communication occurs within, and for, the individuals themselves.

Goldin Meadow explains how thought and gestures are connected during communication. She further adds that to ignore gestures is to ignore part of the conversation (Goldin-Meadow, 2005). She states that gestures possess an inherent, visually symbolic representation of meaning not often encountered in speech (ibid). Both authors assert that speech and hand gestures are linked "in timing, meaning and function" (ibid), and that gestures provide information that is

either not verbalized or verbal information that needs to be augmented. Thus, just as speech is considered vital for communication, gestures, which are linked to speech, are an integral part of the communication process. More importantly, they are "essential if our goal is to fully understand what people are thinking about as they talk" (ibid).

In addition to examining the importance of gestures in communication, both Goldin-Meadow and McNeil categorized gestures by linking them to the thoughts of the speaker. Before the research phase began, there was a need to identify the design relevant gesture groups to develop a well organized gesture taxonomy that distinguished between those were used for design communication and those that were not. By categorizing the gestures, it was understood which gestures would be appropriate to be applied towards a solution. Goldin-Meadow (2005) and McNeil (1992) both use six categories of gestures that occur while communicating, including:

1. **Iconics:** indicate pictorial entities and state the motion and shapes of objects that are tangible. They occur along with speech. (Example: A designer makes a twisting motion in the air while saying 'the bottle opens like this)
2. **Metaphoric:** refers to a pictorial objects as well, but are focused on more abstract notions. A metaphor that is gestured referring to an invisible object. (Example: A designer gestures referring to a product they saw in a book last week)
3. **Diectic:** is the pointing gesture that when performed is "indicating objects and events in the concrete world" (McNeil, 1992). These objects don't necessarily

need to be in sight of the user. (Example: Pointing towards a sketch in the speaker's space and talking specifically about it)

*Figure3: Example of Diectic Gesture*

4. **Beat:** Gestures form the rhythmical motion associated with speech, with the gesture movement associated with the tone of the speaker. (Example: A designer making a point while waving their hands rhythmically while addressing an audience)
5. **Emblems:** Gesture that occurs in the absence of speech and is culturally understood. (Example: The O.K. sign)

*Figure4: Example of Emblem Gesture*

6. **Adaptors:** User has little awareness of the gestures being performed and no intent to communicate. (Example: Rubbing your chin)

The metaphoric and iconic gestures refer to the pictorial, with the iconic referring specifically to a "concrete object or event" (McNeil, 1992), while the metaphoric

"represents an abstract idea"(ibid). Another difference between the two is that Iconics occur simultaneously with speech, while metaphorics can occur without speech. Diectics are the familiar 'pointing' gestures that are "used to indicate objects, people and locations in the real world" (Goldin Meadow, 2005). Beats, adaptors and emblems are the other gestures they define as communicative tools. Beats and adaptors are more intrapersonal, where information is not being communicated, but being used to form thoughts in the speakers mind. The categories were very important for this study as they established the metrics the research phase would focus on. Without the categories it would become increasingly difficult to understand which gestures relate to group design communication and which are intended more for intrapersonal communication.

**Design**

Design is the process by which "concepts and specifications that optimize the function, value and appearance of products and systems"(IDSA, 2004) is conducted by designers. Designers are the practitioners of design subjects such as "aesthetics, semiotics, color theory, and the like" (Hauffe, 1996) whose "analysis and presentation of objects are addressed through a study of geometry, perspective and proportion" (ibid). For this study, it was essential to understand the type of information designers were trying to communicate as well as the components they used to achieve their communication. Understanding design communication and practices were important, as the end goal of this project was to design a solution that could be used to improve communication among

designers. For instance, designers tend to express the shape of their designs, as "recommendations through drawings, models and verbal descriptions," (IDSA 2004) during design presentations. A solution would have to incorporate this methodology of design presentations, as the purpose of this study is to augment design presentations rather than change the manner in which they occur.

Design is a co-creative process that occurs in phases where the products being conceptualized and created are shared among individuals within collaborative groups for the purpose of discussion, feedback and developing group consensus. The phases of co-creation are not always linear, but mostly involve the creation of prototypes, explanation of conceptual designs (e.g., through sketches and models) that explore the attributes of a product, and the understanding of end user behavior, needs and choices. As Hauffe explains, sketches and models are expressions of aesthetics and semiotics and embody the exploration a designer makes during the creation of a product. Sketches act as a language through which issues of form and functionality are displayed. Successful communication relies on the tools and materials such as sketching, model making, brainstorming etc., in the creation process of ideas. Sharing these materials is paramount, as they act as vehicles for the effective communication in a group.

Certain design studies, such as that conducted by Hummels and Stappers(1998) had utilized gestures for the purpose of design sketches. They set up experiments where gestural human-computer interaction for product design was studied to create sketches of a given object. They strongly believed that conventional

mouse-based design packages with their standard rendering software lacked the subtlety that a sketch drawn by hand with a pen on paper could provide. They attempted to understand how gestures could bring back this loss of subtlety. Their results showed that gestures and their meaning can be recognized by a trained artist. Their subjects were capable of describing sketch features such as surfaces, height and 'revolvingness' while using gestures, establishing that gestures can be involved during the transfer of design related information. However, while this project was informative for categorization and gesture usage, their experiments were not context specific and therefore lacked a connection between gestures and the circumstances in which they would be beneficial. Also, the study was left at the research phase without suggesting any design criteria.

Hatch et al. (2006) provided evidence about how designers employ various processes in co-creating products. They even suggest the importance of improving communication between designers using new tools along with the "conventional means by which designers communicate (drawings, renderings, models and prototypes)" (ibid, p. 59). This suggests that certain processes that are employed by designers and provided a holistic view on what it takes to create products. It also identified the importance of physical design components for the purpose of communication.

## Technology

This section explores the incorporation of technology into the products and systems with which humans interact. A relationship between hand gestures, design and technology has become a common paradigm for many hi-tech projects, ranging from the kitchen (e.g. touch screens on refrigerators) to computing (e.g. the navigation of virtual and augmented spaces). In this section we explore the possibilities for the natural interfaces that have opened up due to the increased importance of information technology in our daily lives and how technological projects have incorporated new paradigms for interfacing.

This section is categorized into two areas: Technological Devices and Technology Considerations. These two sections, respectively, provide an overview of the studies that have attempted to incorporate hand gestures as a non-standard interfacing paradigm in technology and the important issues that a designer needs consider when using a technological system to aid gestural communication.

### Technological Devices

This section provides an overview of various projects that examined the use of technologies, from consumer electronics to ubiquitous computing, to facilitate gestural communication. Many of these projects were successful in creating prototypes and testing their hypotheses, but were unable to incorporate a human-centric, evidence-based approach to their projects. For instance, Omata

et al (2003) suggest twisting the hands to perform functions on a computer, yet they lack research support as to whether the specific twist is appropriate for the function it performs. Although some gestures might be obvious when translated (such as picking or pointing), other more complex gestures that require the movement of the hands need to be backed by research. Finally, while there is literature that suggests that gestures can be appropriate interface tools, there is a lack of mapping appropriate gestures to functions.

Other projects that used gestures considered them to be "ubiquitous in the environment interactions" (Karam 2006) which suggests that they can be implemented with technology to aid design communication. In contrast, Chik et al.(2007) did not utilize hand gestures, but developed a new method of mind mapping, using a pen as a prop to gesture with. Mind mapping is the exploration of thoughts that is conducted within a group. The pen is an appropriate prop as it acts as an extension of the user's body, making it the interaction medium between a user and a technology. Furthermore the researchers state that "sketch-based computer tools have found that using ink (digital ink) is preferable to widgets for design tasks such as user interface design, multi-media design and graphic design" (Chik et al, 2007). These projects revealed how gestures, in one form or another, were being used in the co-creative process as well as established that a pen might be used as a means to interact with a system, rather than using only hands.

Wilson (2007) used depth-sensing cameras in vision-based human computer interaction scenarios such as games and gesture input systems to detect, interpret and take actions based on the sensing. This type of non-intrusive technology has the potential to maintain the naturalness of communication, as the users do not have to make changes within themselves. The use of technology to recognize gestures in the work of both Wilson (2007) and Chik et al. (2007) supports the feasibility of developing a communication tool based on hand gestures.

Pattie Maes and Mistry (2009) presented their version of a gesture-based system that allowed for detection of hand gestures in any environment. In their Sixth Sense concept a user "would walk up to any surface and use his hands to interact with the information" using "natural gestures" (Maes and Mistry, 2009). Using off the shelf mini projectors and cameras, the system would detect any hand gestures being performed and then provide an output based on that gesture. For example, by performing the emblematic gesture of taking a photo, the system would take a photograph.

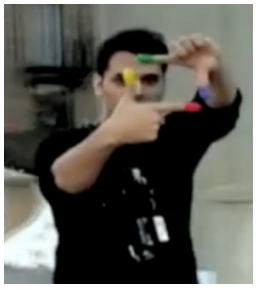


*Figure5: Sixth Sense gesture to take a photo*
*Mae and Misrty (2009)*

Although this project was successful in providing instances where gestures could be incorporated into our daily lives, the project used gestures similar to the ones

already in use by current technology as well as the gestures being performed were simple. The users also had to wear finger caps for the system to detect the extremities of the fingers.

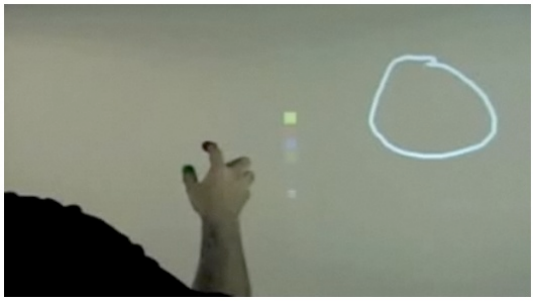


*Figure6: Sixth Sense demo*
*(Maes and Mistry, 2009)*

Wisenski (1998) and his group at MIT suggest the use of architectural spaces to embed technology so that it detects and understands the user, rather than the other way around. Although this research does not directly use gestures as a tool for interaction, they do highlight the need for new, more natural and simpler interfaces to be created for providing information to users through physical changes (e.g. sound, light etc.) in their environment.

It is also worth noting how consumer electronic products have started to apply simple gestures for interaction. Nintendo® with its two game consoles, the Wii™ and the DS™, have explored gesture use with props. The Wii™ remote for instance, has built in accelerometers that detect gestures. For example, to spin a character on the screen, a user must spin the remote in a similar fashion (Super Mario Galaxy, 2007). This provides the user with a more immersive and natural experience of playing a video game as their action (gesture) is mapped directly

to the action of the on-screen character. Other companies such as Apple® and HP® have also incorporated gesture recognition into their devices for the purpose of selecting, scaling and moving objects.

Technological Considerations

The writings of John Maeda (2007) and Donald Norman (2002) are perhaps the most prolific and poignant in describing the need for careful consideration of the relationship between users and technology. Both relied on their personal experiences as well as observations to develop theories of human-technology interfaces based on simplifying the relationship between users and technology. Both relied on their personal experiences as well as observations to render their theories. This study considers gestures part of the simplification process as they occur naturally and have the potential to reduce mediation.

For both writers, the ability to analyze tasks and functions, and then simplify them is the key for designing a successful product or system. Maeda and Norman address the need to simplify and improve the products and systems that designers create and present their methods of being able to do so. Both present their own versions of how complicated and unnatural products can cause hindrances in new user uptake and frustration.

Maeda suggests the use of his 10 laws of simplicity including reduce, organize, time, learn, differences, context, emotion, trust, failure, and the one, to design simpler and more effective interfaces (Maeda 2007). Among these laws, the first

four are the most appropriate for this project. Gestures have the potential to reduce the amount of mediation that a user requires to perform a task. The law of reduction becomes extremely relevant when a user is attempting to manipulate an object, or navigate through the information space of a technological product. If a user has to perform many tasks to perform functions that in the real world are natural and simple, the relationship between a user and an object might become hindering. Maeda does not propose a reduction in functionality, but instead a simplification of the process. The reduction in mediation also allows for a reduction in time. The organization of a gesture-based system into design presentations might allow for a further improvement in the relationship. In learn, Maeda suggests the need to consider how long learning how to use an interface can impact the experience of using a technological product. There is potential for gestures to greatly reduce the learning curve associated with using a new interface as the users would not need to spend too much time learning something that occurs naturally. This makes the need to conduct research suggested in this study more important because gestures that occur naturally need to be identified, if they are to be applied towards a solution.

Norman advocates the use of "natural signals" (Norman 2002) that are "naturally interpreted, without any need to be conscious of them"(2002). Gestures are a perfect example of naturally occurring communicative tools, as they occur slightly outside of the conscious threshold.). Norman (1994) also provides important insight into what constitutes interfaces by breaking down each component of an interaction between a technological product and a user. As the expected end

result is an interface that uses gestures, knowing what constitutes an interface becomes extremely relevant. Relying on the explanation of an interface, gestures then have the potential to allow for a natural interface, where the gestures that a user performs (and they will perform them naturally) can now be used interpersonally rather than just intrapersonally.

Other authors also supported the need for new interfaces to be developed and suggested that the current paradigms of interfacing may not be appropriate for the upcoming advent of newer and more advanced technological products, This was particularly important in supporting the conceptual approach of this thesis that natural, more human interfaces are more suited to perform tasks (which this thesis project does state). Dix et al. (1998) supported the need for new paradigms of interfacing. The authors' explanation (based on Norman, 1994, shown in Figure 7) explains what a basic interface involves. According to their description, when users attempt to interact with a technological interface, they start by executing a task by means of an input. This input can often be heavily mediated and unnatural (e.g. mouse clicking to select object, select a function like zoom, perform desired zoom, and then deselect function and object). Then the technology (computer) performs its functions of understanding the input and provides output stimuli that the user evaluates. Hand gestures are expected to become part of this basic interface by being incorporated in the stream as an input that does not require a multiple step process and can be performed naturally.

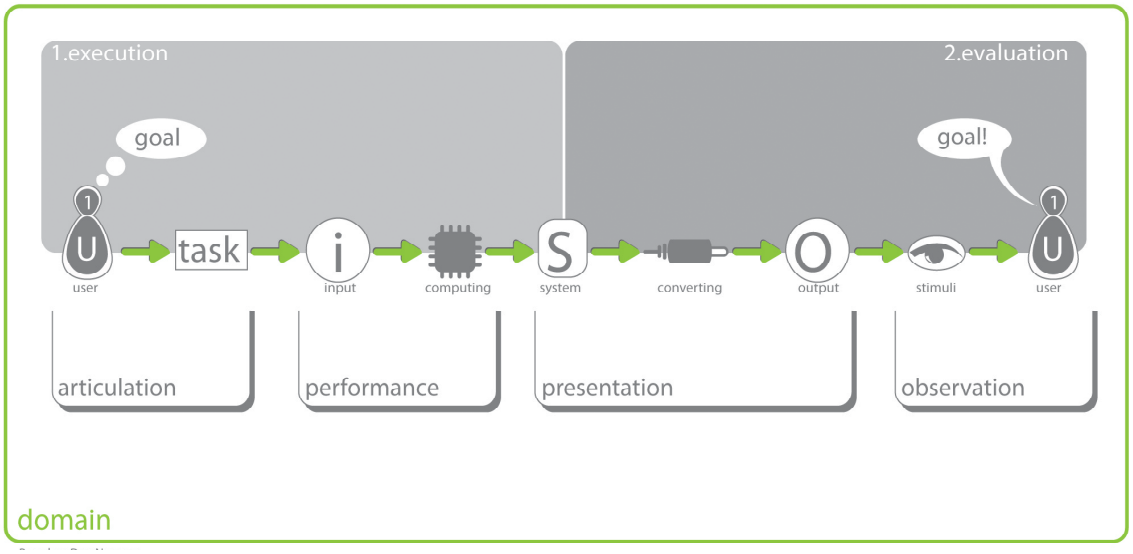



*Figure7: An Interface Spectrum Modified by Norman (Norman 1994)*

**Summary of thoughts on Literature Review**

This chapter summarizes what the literature review provided as relevant information for the grounding of this study. It revealed the following:

- Design practices are performed between multiple people and the sharing of design materials occurs in multiple phases of the design process.
- Design communication is a core part of co-creative design process
- Careful considerations should be made when designing a relationship between users and technology.
- As technological products become more complex, it is important to utilize natural methods of interacting with them.
- Technology has allowed for the detection of humans in non-intrusive manners, allowing for more natural interactions.

- Gestures are an extension of the performers mind and communicate important information about their thoughts.
- Designers rely on design materials (e.g. sketches) to formulate ideas and explore and present their designs.

## CHAPTER 5

## THEORETICAL FRAMEWORK

This chapter discusses the rationale behind the investigation in this thesis project. Research questions are also proposed in this section, serving as a guide for this study.

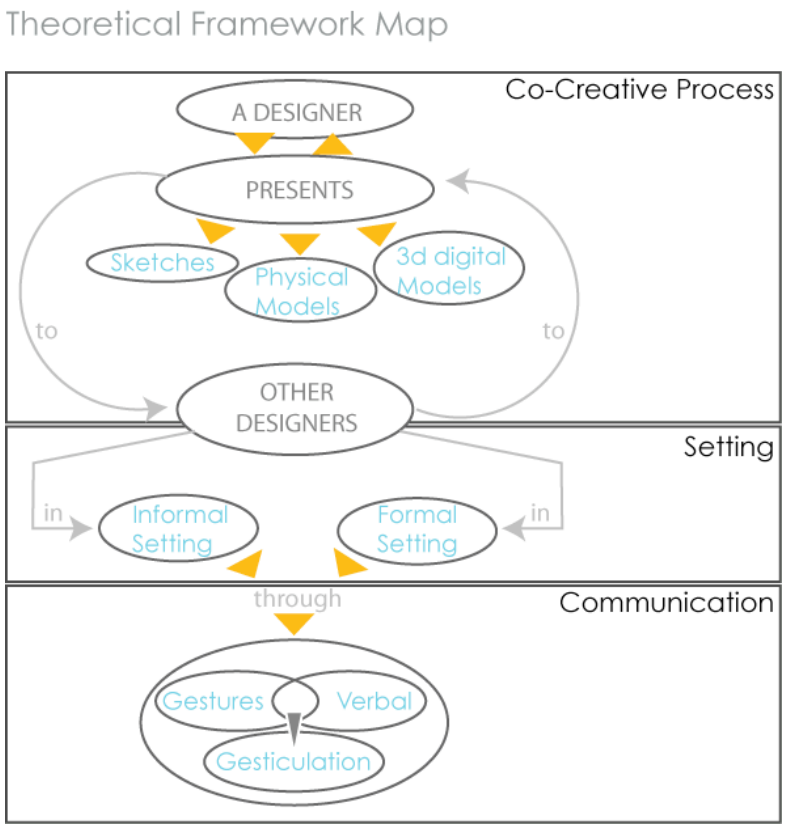



*Figure 8: Theoretical Framework*
*A basic explanation of the theory behind this project*

The theoretical framework illustrated in Figure 8 provides the basis for this study. It summarizes the process in which designers communicate, using sketches and models with other designers. This is referred as the co-creative process where the design material (sketches, physical models, 3D models) is shared amongst a group

for review and consideration. This sharing can happen in either formal or informal settings. Along with the design material, the designers communicate by gestures, speaking or gesticulating (speech and gestures together). The research methodology of this study explores the relationship between all these entities.

According to Goldin-Meadow (2005) and McNeil (1992) gestures are natural extensions of a designer's thoughts, and may contain information that can facilitate communication at an intrapersonal and interpersonal level. If it is possible to harness gestures for the co-creative process, more information can be communicated than what is possible with just speech and static sketches and/ or models. Co-creative design relies on the ability of its participants to communicate. Gestures can have the ability to make static information dynamic by which the information being presented becomes more memorable for the audience. A more dynamic and co-creative process may have the potential to enhance design outcomes by providing a richer, more informative design experience. This potential is explored in the design phase of this project.

This study proposes the need to understand how design communication among a group occurs with a specific look at the role gestures play. In the study of gestures, Goldin-Meadow (2005) proposes different steps: first, identifying gestures in the "stream of motor behavior" (ibid); second, understanding their form; and third, understanding its associated meaning.

**Research Questions**

The hypothesis of this project thesis states that hand gestures can be an effective and expansive tool in design communication, specifically when used along with technology. As such, this study proposes answering the following primary and secondary research questions.

Primary Research Question

**- How can gestures and technology facilitate functions during group design communication?**

Subsequent questions:

- What gestures are linked to concept attributes during group design communication?
- How do gestures differ between formal and informal settings of design communication?
- How can gestures be used to augment the information space during group design communication?

## CHAPTER 6

## RESEARCH METHODOLOGY

In order to answer the research questions and to address each of the specific aims described above, the study design (see Figure 9) will be carried out in two phases, a research phase and a design phase. The research phase of this project addresses the research questions in order to establish design criteria that can be used in the design phase. The design phase, directed by the research phase, addresses the question of if and how gestures can augment the information space during communication.

(Map of phases listed on next page, Figure 9)

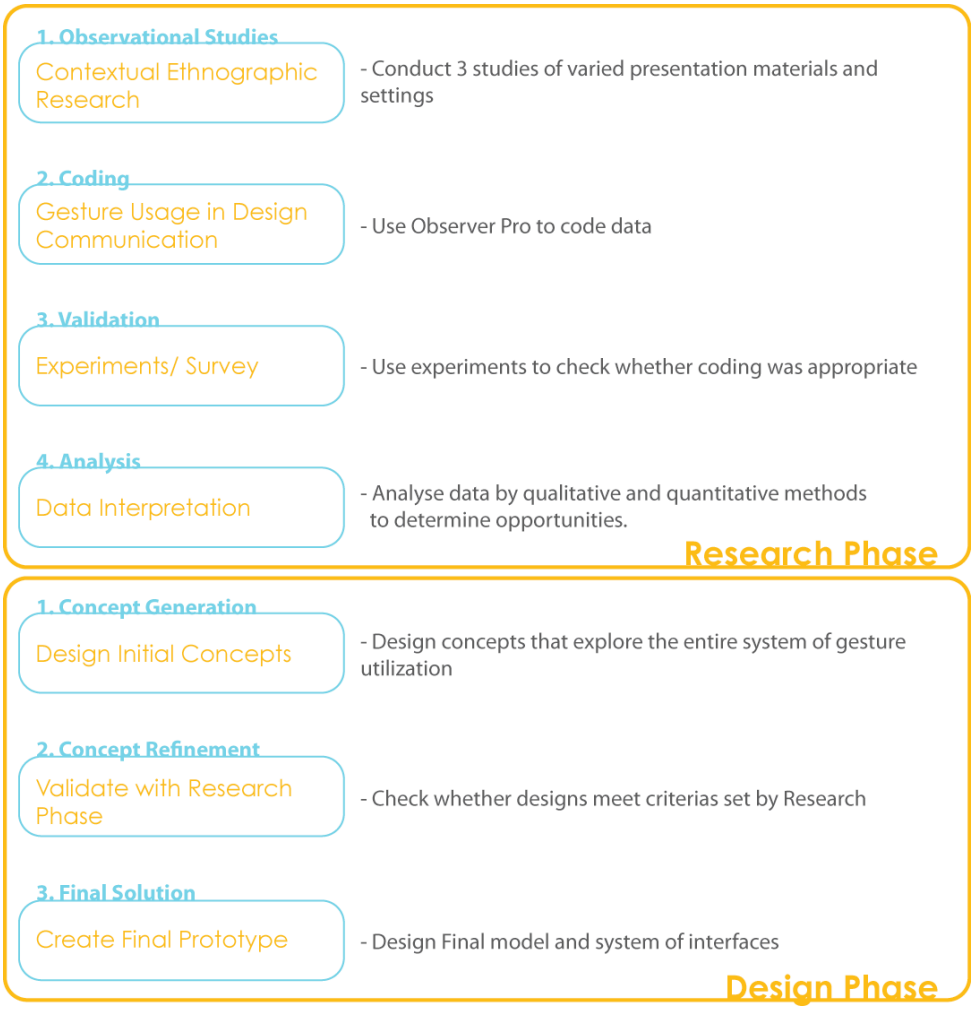



*Figure 9: The two phases of the this study*

**Overview**

The study uses a mixed methodological approach (Creswell, 1994), where both qualitative and quantitative data is collected and analyzed with the purpose of directing the subsequent design phase. This mixed methodology approach is conducted to ensure rich information and data analysis.

The research phase of the project is organized into the following tasks described below:

1. Observational studies: Conducting 3: 2 in formal settings and one in informal settings.

2. Data Coding: Data from task 1 is coded by behavioral categories

3. Validation Study: A survey is conducted to validate coding categories in task 2.

**1: Observational studies**

To understand communication among industrial designers, the data collection occurs in 3 observational studies of design communication: 1) formal presentation setting during design development phase, 2) informal presentation setting during the same design development phase; and 3) informal presentation setting during design redevelopment phase. The studies are conducted in natural environments where 8 design students are observed making presentations in a design studio. The studio phases, entitled: "Design Development and Design Redevelopment," is selected because they involve both formal and informal presentations. The studio includes 16 students, of which half (8 out of 16) are selected at random to participate in the study. The 8 individual students were observed individually in the first study and then the 8 students formed 4 groups of 2 for the second and third study

Although the students are in a design studio, they came from varied backgrounds such as engineering, design and philosophy. This provides an unbiased outlook on design presentations and also checks whether gestures

change based on the material being presented, by the presenter's personal background and whether the informal and formal settings effect how designers gesture.

In the formal presentation setting, the presenter(s) is the only person(s) imparting information to an audience (classmates), and the information sharing was uni-directional. In study 3 we see two presenters presenting, yet, only one of them spoke through one section of the presentation.

In the informal setting, the information sharing was multi-directional, where the audience (a professor) and the two presenters are going back and forth in imparting the information. In each of the studies the participants are recorded using a video camera for the purpose of using the observations in the coding phase.

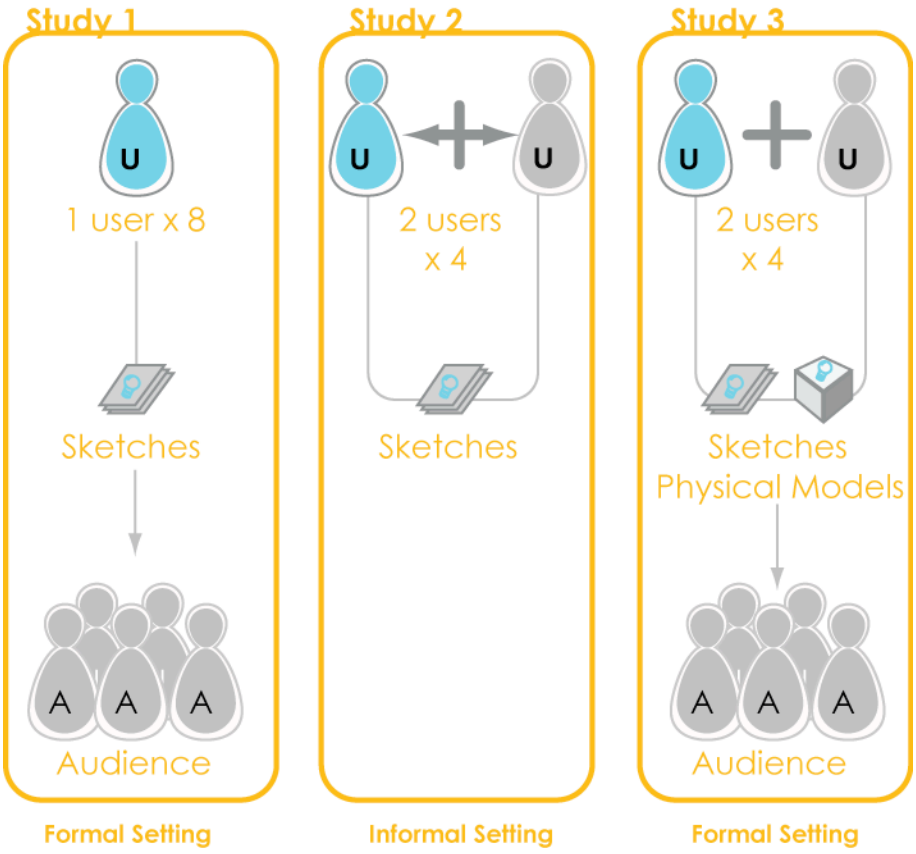



*Figure10: The three studies of the Research Phase*

Study 1: Design Development (formal setting)

Individuals present sketches to an audience where the information is imparted uni-directionally. Here, the participant presents initial concepts of a project via sketches that had been previously scanned, and presents using a projector and PowerPoint.

Study 2: Design development (informal setting)

Individuals present sketches to another individual and an instructor. In this setting, two participants who are working on the same project present concepts using

hard copy sketches whilst in an informal setting. (Multi-Directional)

Study 3: Design Redevelopment(formal setting)

Groups (2 or more students) present physical models and sketches to an audience. In this study, participants are observed presenting more refined concepts using PowerPoint and a projector. In some cases, physical modelsarealso used. The participants are in a group and take turns presenting different sections of their presentations.

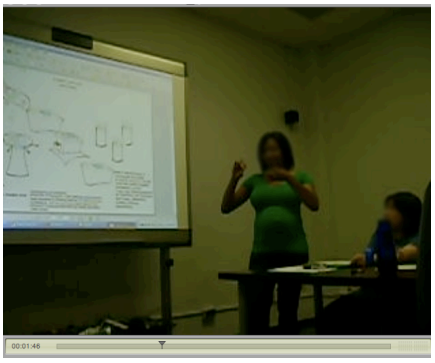


*Figure11: Study 1- Formal Setting*

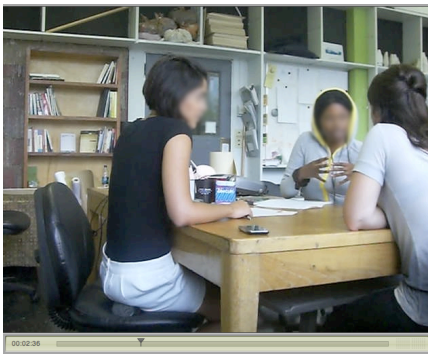


*Figure12: Study 2-Informal Setting*

## 2: Data Coding

### Qualitative Data

During the video recording of the data, the researcher is required to take hand written notes and observe the participants making presentations. This study is important in identifying some behavioral traits of the participants that aid in creating the behavior groups for the data-coding phase. The observations made here are solely on a qualitative approach and include general information about the interaction between users and their materials.

### Quantitative Data

The observations are recorded using a video camera, and the videos are imported into Noldus's Observer XT software. This software allows research data to be categorized as code recorded observations. Behavior groups established from the literature review and observational studies are created to categorize the behaviors being understood. These behavior groups is the *units* that are being measured and are established from sources listed in the literature review as well as observations the researcher makes during the recordings. For instance, the gesture classifications are derived from the writings of McNeil and Goldin-Meadow. The researcher considers only one behavior group at a time. During this time the researcher looks for which behavior within the group matches what the participants are doing. Within each behavior group a participant could only be performing one behavior. For instance, when observing the gesture production behavior group, a participant could only either be gesturing with no speech, gesturing with speech, only speaking or not communicating at all.

The list below describes the various behavior groups and the behaviors that are coded with a brief description of the behaviors being coded. These behavior groups are established because the "key to any study of gesture is its coding system- isolating gesture from the stream of motor behavior, describing its form, and assigning it meaning" (Goldin-Meadow 2005, p. 11).

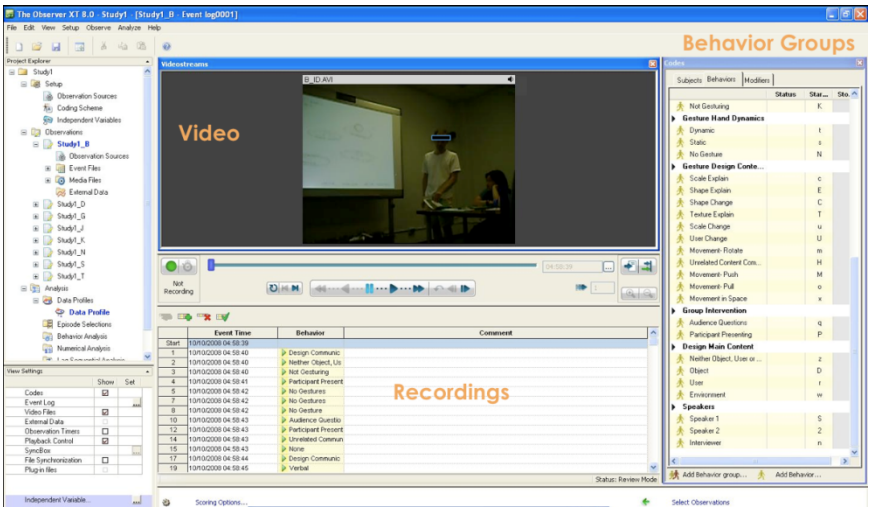



*Figure13: Screenshot of Observer XT*

*The video is in the center and the behavior groups are listed on the right. All recordings are listed below the video.*

1. GESTURE PRODUCTION: In this section, what type of communication (verbal, non-verbal) is being performed is noted.

1. Gesture Alone: Gesture without any words
2. Gesture + Verbal: Gesticulation
3. Verbal Alone: Only Speech
4. None

2. GESTURE CLASSIFICATIONS: The following classifications of gestures are adapted from Goldin- Meadow (2005) and McNeil (1992). This section describes what type of gestures participants are performing during design communication.

1. Iconics: Gesticulation. Concrete. Body Movements, Movements of Objects or people in space, shapes
2. Metaphoric: More Abstract. Motion.
3. Diectic: Pointing at a real 'object'. Gave it to her...etc. Pointing does not need to be at a visible object
4. Beat: Up down In out motion. Rhythmical Pulsation of Speech
5. Emblems: No Speech. Meaning understood without words.
6. Adaptors: Little awareness and no intent to communicate.

3. GESTURE COMMUNICATION: In this section, the main content of communication is recorded to establish what percentage of a presentation relates to design communication.

1. Design Communication: Content relates to design concepts.
2. Non-Design Communication: Content relates to anything besides design related.
3. Presentation Communication: Content relating to the presenting of material. E.g. On the other page, Go to next slide...etc.

4. GESTURE MORPHOKINETICS: In this section, the movement and position of the hand gestures relative to the speaker are recorded.

1. Towards Self One Hand

2. Towards Self Two Hands
3. Towards Object One Hand
4. Towards Object Two hands
5. Towards Audience One Hand
6. Towards Audience Two hands

5. GESTURE HAND DYNAMICS: This section relates to whether the gesturing is occurring through moving hands or non-moving hands.

1. Dynamic: Hand(s) Moves. Motion used for communication.
2. Static: Hand(s) display content and do not move while communication.

6.ATTRIBUTE COMMUNICATION: In this section, the various design attributes that participants are gesturing about was recorded.

1. Scale Change: Changing the scale of a component. e.g. It becomes this much bigger

2. Scale Explain: Suggesting the scale. e.g. This is how big it is.

3. Shape Change: e.g. It will look like this from this.

4. Shape Explain: e.g. This is what it looks like

5. Texture Explain: Gesturing the attributes of a material

6. User Explain: Gestures used to describe the user

7. User Change: Gestures used to denote the changing from one user to the other.

8. Movement: e.g. rotates, pushes, pulls, presses, Drops etc.

7. DESIGN MAIN CONTENT: This section records what the main area of communication that the participants are referring to.

1. User: Participants refers to the users in their con
2. Space: Participant talking about the environment
3. Object: Participant talking about the Object.

**3: Validation Study**

The validation phase focuses on testing whether the categories and gesture mapping conducted in Phase 1 is appropriate. The Validation phase is used to confirm the accuracy of the observational studies. During this study, subjects confirm a set of gestures linked to a specific function by answering a multiple-choice questionnaire. The participants are validating the gestures of scale, rotation, layers, pushing, pulling, next, pointing, environment, dimensions and shape, which are common attributes presenters from the ethnographic research communicate.

The study is conducted with 14 subjects selected from a pool of design students. The students represent diverse educational backgrounds but are all studying design currently, and who have not previously participated in the research. As it is expected that there will be numerous behavioral categories, 14 subjects are included to provide sufficient data.

In the validation study, subjects are shown videos of gestures performed by an actor. The gestures that the actor performed are derived from the ethnographic

research presentations. The subjects are tested (through a multiple choice) on whether they understand what the gesture is supposed to relate to. The multiple choice lists 4 options for the participants with one answer being the best answer (Choice 1), and another being a good choice (Choice 2). The actor does not speak during the performance of the gestures. The accuracy with which the subjects understand the gesture is used to validate whether the application of a gesture to a function is appropriate. The 'acting' is directed by the gestures that were cataloged in the observational studies, coding and observations. The image below (figure 14) shows the video the participants see and the multiple-choice questionnaire.

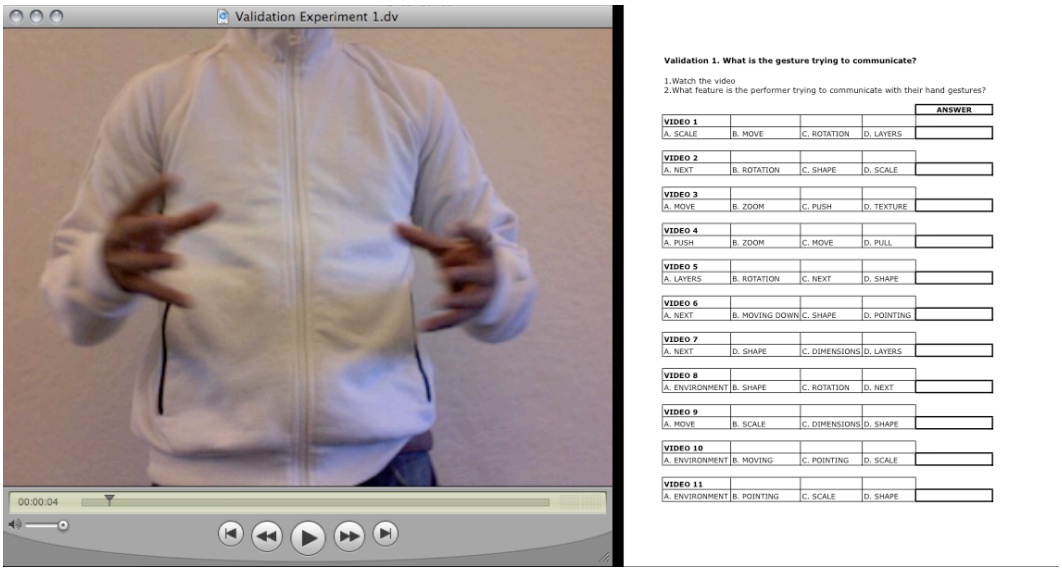



*Figure14: Validation Study: Understanding gestures*
*This set of images show the video the participants are shown in Study 1 and the questionnaire they will answer.*

# CHAPTER 7

# RESULTS AND DISCUSSION OF RESEARCH PHASE

## Results

### Observational Studies

During the observational studies 8 students were observed in three studies.

Study 1: Formal setting with the participants (B,D,G,J,K,N,S,T) presenting individually .

Study 2: Informal Setting with participants (B_G, D_K, J_T, S_N) presenting in a group.

Study 3: Formal setting with participants (B_G, D_K, J_T, S_N) presenting in a group.

1. Qualitative Data

In this section we note some key observations that were made while the researcher was recording the studies as well as viewing videos afterwards. Some of the main points are highlighted here.

Study 1 Observations

During this formal presentation, presenters tended to rely on gestures that referred to an object by using Iconic, Metaphoric and Diectic gestures. Design ideas were presented through sketches only. The presenters would consistently fill in gaps of information that the user might have left out in their sketches by

creating a dimensional space of the environment (e.g. things are either left, right above their sketches) (Participants N, G). When referring to their concepts some participants talked about their concepts, ideas and 2D objects as tangible, manipulating them using their hands (Participant K, N). It was also noted that the audience looked towards the projection screen more than the presenter.

Study 2 Observations

In study 2, the participants were asked not only about the concepts that they presented through sketches but also how they collaborated. When talking about their sketches, the participants tended to gesture in space (metaphorically) when talking of their concepts as a whole but were more deictic when presenting attributes. (Participant B,D). Participants 'selected' what part of their sketch they were referring to and then metaphorically gestured attributes (e.g. shape).

Some participants did not seem to be hindered with a prop in their hand, such as a pen (Participant S). This participant used the pen as an extension of their hand and when they gestured with two hands, the hand holding the pen would symmetrically follow the one holding the pen.

The most common gestures, when being iconic or metaphoric related to the motion or animation of the objects in their concepts and these gestures, used the entire hand, except when using deictic gestures, where they used either their index finger or pinky finger.

Study 3 Observations

In this study we saw participants behaving similarly to Study 1. During this study the participants presented their ideas using physical models as well as sketches. Participants needed to stretch their hands towards the projected screen whenever they had a visual representation (e.g. Sketch). This stretch selected what they were going to gesture about and then they would gesture metaphorically. After the stretch to select the area of the sketch they would return to their normal pose, and perform the gestures in front of their bodies.

Gestures were reduced or not performed whenever there was an animation on the screen itself (B_G). Some participants made short movies explaining their concepts, but either only communicated verbally or gestured using adaptors. (S_N)

Also, like in Study 1, it was seen that features of objects, such as wings (D_K) were animated or moved using gestures. This group had a physical model where the wings moved, but the participants only pointed at the wings and then gestured their movement.

2. Quantitative Data

The results from the quantitative data derived from Observer Pro revealed that part of the hypothesis was grounded, in that gestures do form a large part of design communication. Along with gestures being a communicative tool, the data also revealed what the designers were communicating in terms of content,

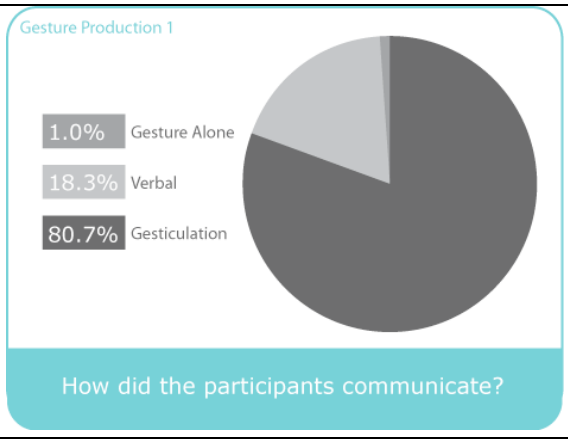
as well as how the gestures were being performed. Based on the behavior groups established above, listed here is a summary of the statistical findings. The results are then analyzed in the next section. All the concrete data is listed in appendix II.

To get the overall percentages of the study, the percentages from each study were added together and divided by the number of total studies (e.g. 3 total studies). To get the percentages of each study, each behaviors percentage was added and then divided by the number of participants. In some behavior groups a participant may not be doing anything related to the group. In those cases, none activity was removed from the percentage calculation, as only when a participant was communicating was data being collected.

- GESTURE PRODUCTION:

Within this behavior group gestures formed a large part of communication. Listed in this section are the frequencies for the forms of communication (i.e. verbal, gesticulation or gestures alone) that were observed.

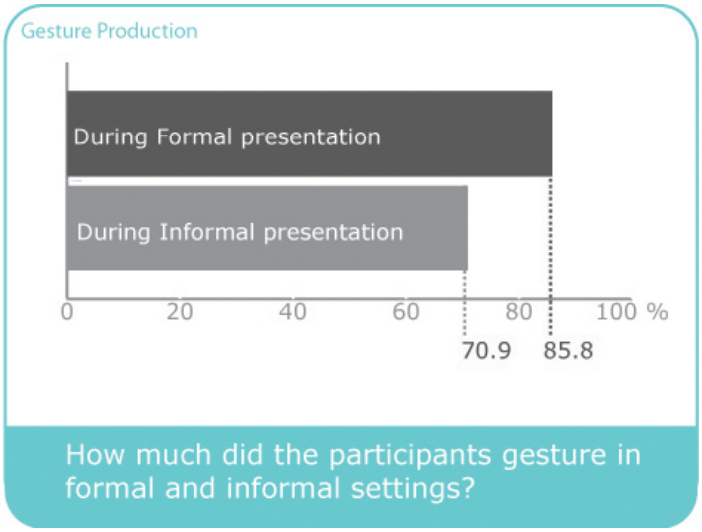
*Table 1: Communication method*




| Gesture Production Summary by Study (%) | | | |
|---|---|---|---|
| | **Verbal** | **Gesticulation** | **Gesture Alone** |
| Study1 | 12.5 | 86.9 | 0.3 |
| Study2 | 26.7 | 70.9 | 2.4 |
| Study3 | 15.3 | 84.7 | 0.0 |

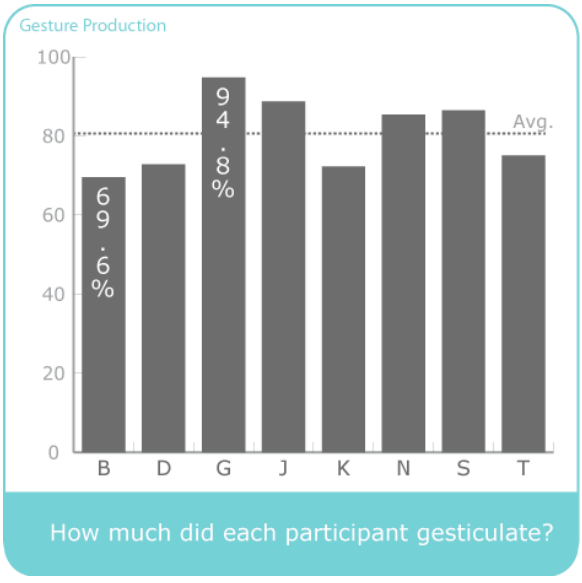
When designers were communicating, gesticulation and a combination of speech and gesturing, was used 80.7% of the time (average across all three studies). Gesticulation was the preferred form of communication in each study.

*Table 2: Gesture Production in formal-informal settings*




The frequency of gesticulation was higher during formal presentations than informal presentations.

*Table 3: Frequency of Gesticulation by participant*



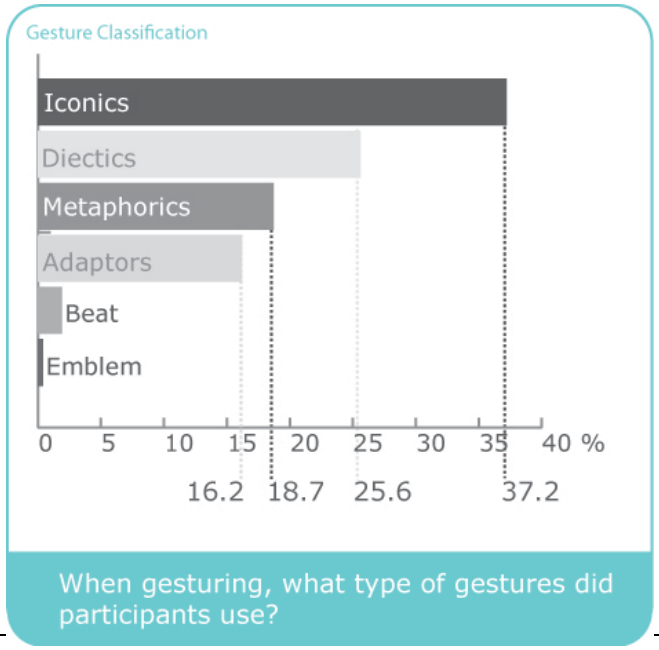
When looking at individual participants (e.g., B,D,G etc. in table 3), we notice that all participants gesticulated the majority of the time, with participant G gesticulating 94.8%, and participant B 69.6%. These two participants were the highest and lowest gesticulators respectively.

- GESTURE CLASSIFICATIONS:

Based on a typology derived from McNeil and Goldin-Meadows classifications, the most frequently occurring gestures by study are listed here.

Table 4: Gesture Classification Results

| **Gesture Classification Summary by Study (%)** | | | | | | |
|---|---|---|---|---|---|---|
| | **Iconics** | **Metaphorics** | **Diectic** | **Beat** | **Emblem** | **Adaptors** |
| **Study1** | 39.4 | 13.2 | 21.9 | 1.5 | 0.9 | 23.0 |
| **Study2** | 36.0 | 18.8 | 22.5 | 3.9 | 0.2 | 18.6 |
| **Study3** | 36.2 | 24.7 | 33.4 | 0.0 | 0.0 | 5.7 |



As illustrated by the table above, gestures that related to something physical were most common. Iconics, Metaphorics and Diectics, all refer to something physical. Iconics formed the most commonly occurring gesture at 37.2%. Diectics, which refers to the pointing towards an object, ranked high as well at 25.6%. The trait of Iconics, Diectics and Metahphorics being ranked 1,2 and 3 was as the most frequently occurring gestures was consistent for each study.

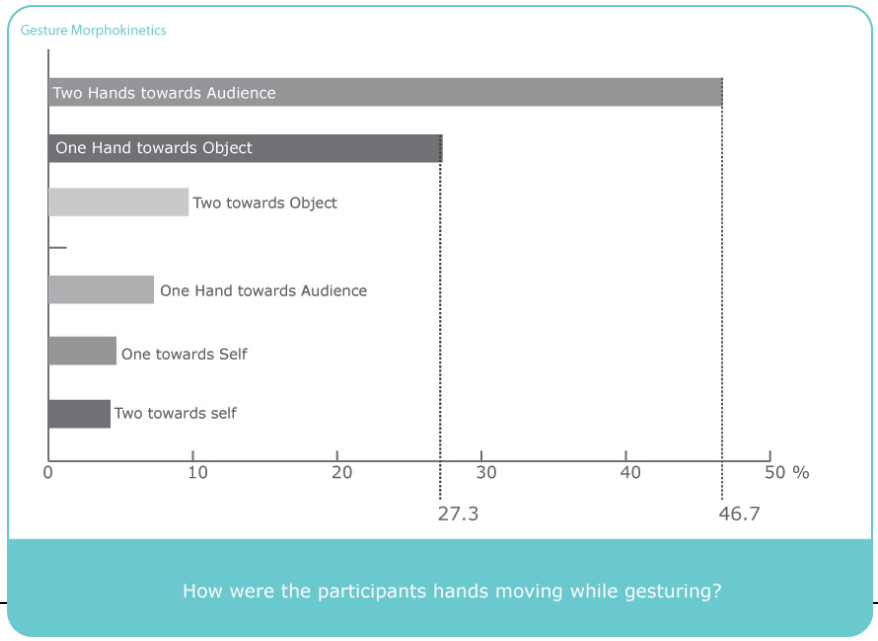
- GESTURE MORPHOKINETICS

This behavior group summarizes the movement of the participant's hands in the space in front of them during gesticulation. The participants during study 2 changed their hand movements more frequently, with the lowest occurring behavior at 8% (one hand towards audience). The lowest for the formal studies was 0.7. During the formal studies one hand towards object was also performed often (31.5% and 39.8%).

Participants moved two hands towards the general direction of the audience 46.7% of the time. This was the only consistent behavior between all three studies. They also pointed or referred to an object (sketch, model, projection etc.) 27.3% of the time.

*Table 5: Gesture Morphokinetics Results*

| **Gesture Morphokinetics Summary by Study (%)** | | | | | | |
|---|---|---|---|---|---|---|
| | One hand towards Object | One hand towards Self | One hand towards Audience | Two Hands towards Object | Two hands towards self | Two hands towards Audience |
| **Study1** | 31.5 | 0.7 | 10.7 | 6 | 1.8 | 49.3 |
| **Study2** | 12.2 | 9.9 | 8.0 | 12.9 | 10.0 | 47.0 |
| **Study3** | 39.8 | 3.2 | 2.6 | 10.4 | 0.7 | 43.4 |



- ATTRIBUTE COMMUNICATION:

When communicating the various attributes of a concept, gestures were performed to change or explain those attributes. During Attribute communication the participants referred to the various attributes and spoke about them for long periods as well, especially in Study 1, where 5 of the 9 attributes were communicated around or over 10%. Listed below is the summary of attribute communication by Studies 1,2,3, with the graphic illustrating the average of all three studies.

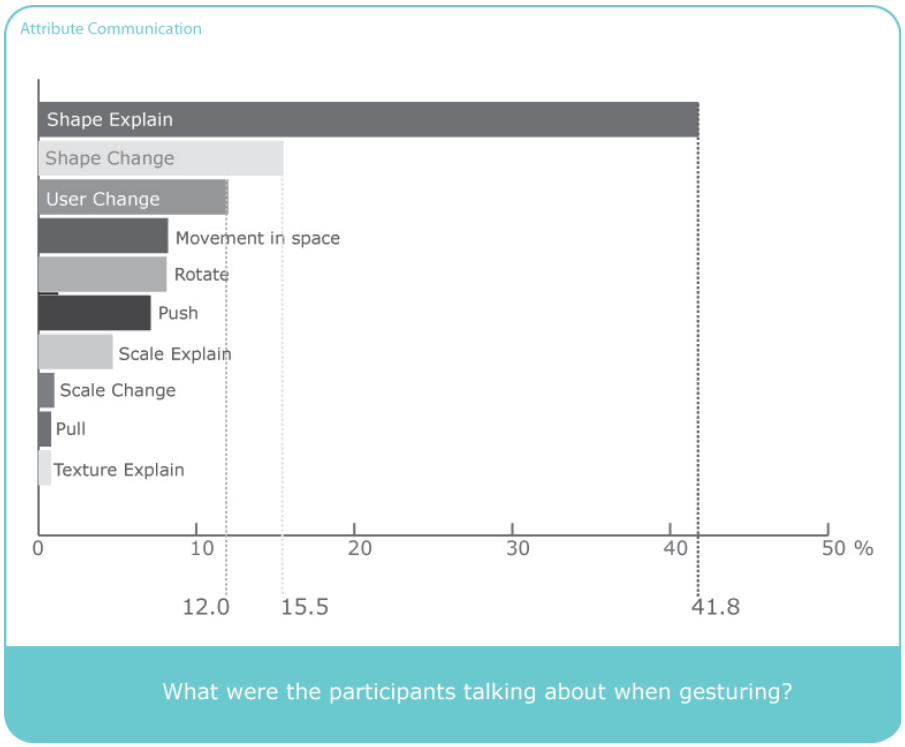
Table 7 indicates that participants used gesturing most often to explain the shape or form of their concepts, communicating this 41.8% of the time. Gestures that were used in conjunction with the changing of shapes was performed the second highest number of times. Pulling, Texture Explanation and Scale Change were insignificant in each study as well as overall. They were in the bottom three in each study.

*Table 6: Attribute Communication Results Summary*

**SUMMARY OF ATTRIBUTE COMMUNICATION BY STUDY (%)**

| | Scale Explain | Shape Explain | Shape Change | Texture Explain | Scale Change | User Change | Rotate | Push | Pull | Movement in Space |
|---|---|---|---|---|---|---|---|---|---|---|
| **Study 1** | 5.6 | 26.4 | 16.4 | 1.3 | 2.8 | 15.7 | 9.9 | 11.9 | 2.4 | 7.6 |
| **Study 2** | 3.5 | 37.1 | 9.8 | 0.3 | 0.0 | 18.5 | 10.5 | 7.5 | 0.0 | 12.8 |
| **Study 3** | 5.0 | 64.8 | 21.1 | 0.7 | 0.2 | 0.5 | 3.1 | 1.0 | 0.0 | 3.6 |

*Table 7: Attribute Communication All Studies*

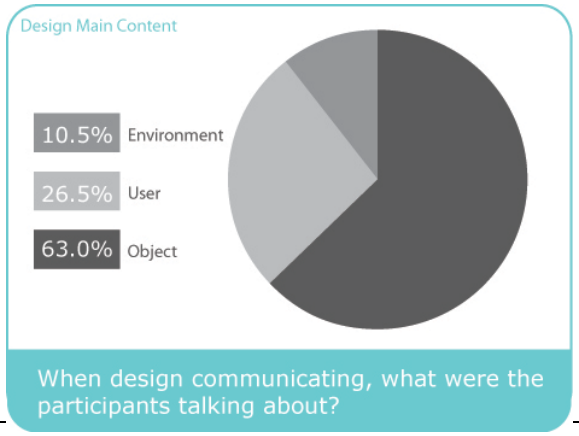



- DESIGN MAIN CONTENT

Design content was divided into three broad categories of information referred to by participants. These included: object, user or environment. As indicated by Table 8, participants referred to objects the majority of the time and significantly more often than either environment or user.

*Table 8: Design Main Content Results*

| Design Main Content Summary by Study (%) | | | |
|---|---|---|---|
| | **Object** | **User** | **Environment** |
| **Study1** | 55.2 | 25.6 | 19.2 |
| **Study2** | 71.7 | 25.5 | 2.9 |
| **Study3** | 69.3 | 21.5 | 9.2 |




Participants were concerned with the object most of the time when communicating their content. In each study, the object was the most common design communication

- GESTURE MOVEMENT

In this behavior group, gestures performed were categorized as either dynamic, (they moved to communicate) or static (the hand would move to a position and remain there). As expected, the gestures were mostly dynamic (77.9%) rather than static (22.1%). The static data relates to the Diectic gestures that were performed, which occurred 25.6% of the time.

*Table 9: Gesture Movement results*

| **Gesture Movement (%)** | **%** |
|---|---|
| **Dynamic** | 77.9 |
| **Static** | 22.1 |

- PARTICIPATION

During the studies, members of the audience and/or the instructor also participated with feedback and comments. During studies 2 and 3, the participants were paired, and it was important to see whether the participants formed the core communication during the group. As an average, at least one participant being studied was communicating 42.2 % of the time, with the highest participant communicating 98.8% and the lowest 3.2%. The median for this data was 41.5.

**Validation Study**

The multiple-choice questionnaire used included both a best answer (Choice 1) as well as a good answer (Choice 2), so that richer results could be derived. The percentages reported under each choice in table 1 indicate the percent of the 14 participants that chose that option. For instance, the gesture for scale in video 1, which was the best answer, was correctly identified by all the participants (100%). We note that 8 out of 9 times the participants picked Choice 1, matching the researcher's perception of the video. Also, only once (video 5) did the participants not pick either Choice 1 or Choice 2. All the participants picked

choice 1 for the gestures of push, pull and scale. Only once (video 6) did more participants pick choice 2 over choice 1.

*Table 10: Results of Validation Study*

| RESULTS OF UNDERSTANDING GESTURES BY VIDEO | | | |
|---|---|---|---|
| VIDEO1 | CHOICE 1 | CHOICE 2 | OTHER |
| | SCALE | MOVE | |
| | 100% | | |
| VIDEO2 | CHOICE 1 | CHOICE 2 | OTHER |
| | ROTATION | SHAPE | |
| | 93% | 7% | |
| VIDEO3 | CHOICE 1 | CHOICE 2 | OTHER |
| | PUSH | PULL | |
| | 100% | | |
| VIDEO4 | CHOICE 1 | CHOICE 2 | OTHER |
| | PULL | PUSH | |
| | 100% | | |
| VIDEO5 | CHOICE 1 | CHOICE 2 | OTHER |
| | NEXT | LAYERS | ROTATE |
| | 57% | | 43% |
| VIDEO6 | CHOICE 1 | CHOICE 2 | OTHER |
| | LAYERS | NEXT | |
| | 29% | 71% | |
| VIDEO7 | CHOICE 1 | CHOICE 2 | OTHER |
| | SHAPE | ENVIRONMENT | |
| | 79% | 21% | |
| VIDEO8 | CHOICE 1 | CHOICE 2 | OTHER |
| | DIMENSIONS | SCALE | |
| | 71% | 29% | |
| VIDEO9 | CHOICE 1 | CHOICE 2 | OTHER |
| | POINTING | ENVIRONMENT | |
| | 79% | 21% | |
| VIDEO10 | CHOICE 1 | CHOICE 2 | OTHER |
| | ENVIRONMENT | SHAPE | |
| | 86% | 14% | |

Table 10 summarizes the results of the multiple choice questionnaire. The percentage states the number of participants that got that option right.

**Discussion**

The research conclusions are focused on addressing the research questions in order to derive a set of design criteria that will guide for the next phase of this study.

**Observational Studies**

1. Qualitative Data

There were three main issues derived from the qualitative analysis. First, there was a need for the participants to supplement their sketches with gestures. The sketches seemed to lack information, probably due to their static nature. As a result, participants needed to animate attributes and specific areas in the sketch. There was a consistent attempt, on part of the participants to enhance the information presented in the sketch. Interestingly, the gesturing reduced or adaptors (gestures that do not convey any meaning) were used. As a result, sketches were not needed to information as the animation was doing that.

Second, the participants point to areas in their sketches they were talking about using deictic gestures. In the formal presentations, this action needed more mediation by the participant, as they would often have to walk across the projected screen and/or stretch their hands. As there are many components in a

sketch, the pointing was imperative to get the participant's point across, as the participant needed the audience to be aware of what was being referenced.

Thirdly, during the formal presentations, the audience seemed to focus on the projected screen rather than the presenter. This could be because the room was darkened to improve the visibility of the screen, and the presenters were standing to the side of the projection. This meant that the audience probably missed most of the hand gestures being performed, as the gestures tended to occur in the space right in front of the presenter.

2. Quantitative data

In this section we analyze the data from the Phase 1 Results and learn lessons of what the data is stating.

- GESTURE PRODUCTION:

In the gesture production category data indicate that a high percentage of participants gesticulated when communicating (80.6%), suggesting that thoughts that could not be verbalized alone, used gestures as an aid. This number increased even further (85.8%) in the formal setting as the communication was with a larger group as well as the material (slides) was not tangible and movable. These data confirm that gestures are a vital part of communication, especially when talking about design content, as the physicality of concepts can be represented through gestures.

- GESTURE CLASSIFICATIONS:

The importance of gesture classification is to differentiate the importance of gestures being used to describe something tangible rather than just adaptors. Iconics, Diectics and Metaphorics were the most common gesture type. The iconic and metaphoric gestures suggested that the object and its attributes were of importance to the participants, where gestures filled in the gaps in communication relating to shape and size, as well as the attributes that were not presented in the design material. The deictic suggested that specific attributes needed to be highlighted for the audience, thus the pointing towards them. As the participants talked about one attributes relationship to the other, the one hand would move around the information space.

- GESTURE MORPHOKINETICS

In this category we see the movement of gestures was mostly performed with two hands facing or towards the audience, as well as one hand gesturing towards the object (e.g. sketches, models, parts of slideshow). The two hands presenting towards the audience suggests the necessity for the participant to communicate their thoughts to the audience, thus the expression towards them.

Morphokinetics also showed a slight discrepancy in gesturing with one hand towards the object between formal and informal settings, with the gesturing with one hand towards the object occurring more often (35.4%) in the formal setting compared to 12.2% during the informal setting. This might have been because the information space (the projection) was much larger in formal settings, making the participants point more towards specific areas of their presentation

and attributes within their presentation. Pointing occurs with one hand. The participants presented multiple images on the same slide as well as lines of text, making it necessary to delineate what part of the presentation they were referring to.

- ATTRIBUTE COMMUNICATION:

In this category we saw participants performing gestures to explain the shape of their objects (41.8%) or how the object changed (15.5%), as well as any movement (that occurred to the objects or their attributes: push, pull, rotate), which accounted for 16.0% of all gesture communication. This implies the need for participants to animate their designs attributes and further explains the need for a more dynamic communication stream. Describing the form of an object is often hard simply by verbal means, as the audience might have preconceived notions of what a description means relative to them. For instance, a "large box" might mean different things to people unless a context was provided for them. This further develops the need for a system that can truly utilize the vast amounts of information gestures actually provide, as gestures were used in the studies to explain these relative attributes.

- DESIGN MAIN CONTENT:

In the design content being communicated 63% of the communication related to the object. For the designers, the object was of most relevance rather than the user and the environment. Whether this was the right approach is not

relevant, as this research was not conducting studies on the appropriateness of communication, but rather on the manner with which the communication occurred. It also suggests that objects within the environment being used by users were the dynamic entities, changing as per their interaction with the user.

**Validation Studies**

The results of this study reveal that a high percentage of participants (79.4%) chose the best option (Choice 1) as the appropriate answer to the gesture being performed. This validates that the gestures chosen by the researcher were appropriate for the design feature. This also suggests that the gestures that were identified by most number of participants (over 85%) could be easily applied towards an interface. There was only one video (Video 6: layers) that was not understood by the majority of the participants as being the best choice and only one instance that the participants did not choose choice 1 or choice 2 (Video 5)

**Design Guidelines/Design Criteria**

Based on the discussion of research findings a set of design criteria was developed to guide the design of a gesture-driven communication tool. A core set of guidelines was created, along with concept specific guidelines that are listed in the next chapter along with images and explanation of the concept. The core, as it suggests, were the main guidelines that were to be considered for all concepts. The individual concepts would add further, more specific constraints to specific ideas that were generated. These guidelines were flexible

and allowed for creativity by focusing on the idea rather than the form and technology. More specific guidelines are presented for each concept in the next chapter as to allow for the exploration of a variety of concepts.

CORE GUIDELINES:

- A presentation aid useful during formal presentations, for one participant to impart information to an audience through a large format (projector)
- Promote the usage of Iconic, Metaphoric and Diectic gestures
- Improve the explanation of the object
- Allow gestures being performed by one hand and two hands.
- Non-intrusive props, where the natural gesturing process is not intruded.
- Augmentation of sketches, 3d Physical Models and 3d Digital models in 2D space.
- Augmentation of 2D Space by allowing editing and additions to the space.
- Facilitation of design features such as scale, shape etc.
- Gestures form part of the interface as well as communicate information
- Gestures are used to navigate through a presentation
- Gestures are used to manipulate design material in real time (e.g. Sketches)
- The performances of gestures by the presenter are visible to the audience by bringing gestures to the forefront of the presentation.
- The inclusion of design material into a presentation occurs quickly and easily.

- The selection of a function for navigation and manipulation occurs quickly and easily.

# CHAPTER 8

# DESIGN PHASE

The design phase, directed by the research phase addresses the question of whether a gesture-driven technological tool can be used for design communication. This phase addressed the area of **concept generation.** This stage focused on how and for what purposes gestures would be used in a system.

The concepts presented here relied on the premise that gestures can augment the information that a user is presenting, and when incorporated along with technology, that augmentation can become seamless and more influential. The discussion highlighted the need for a device(s) that worked along with design presentations and filled the void of information created by static sketches and models. Any solution conceived would have to assimilate design presentation styles, which includes sharing ideas through sketches and models.

## Concept Generation

Four concepts were developed in this phase. The first three concepts were intended to address major issues in the core guidelines. The 4th concept integrated the key features of the first three concepts for evaluation purposes.

### Concept 1: Metaphor

- The product becomes an extension of the presenters hands

- It becomes a metaphor for the content
- It augments the 2d Space by manipulating 'the object' in the physical space.

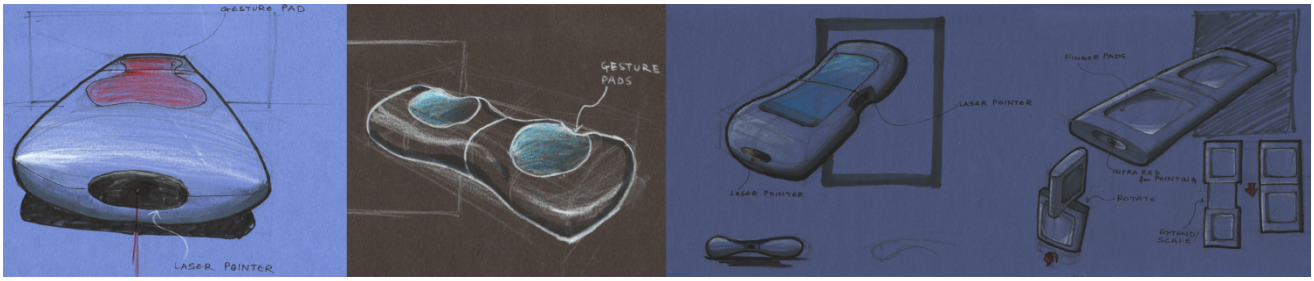



*Figure15: Concept 1- Metaphor*

In this concept, which would be used during formal presentations using a projector and screen, a prop would act as any object that the user was communicating about (A metaphor). This prop would incorporate a laser pointer, for selecting the feature the presenter was referring to and then manipulating it using the prop. It is split into two sides. For instance, if the user wanted to rotate an object they would rotate the two sides of the prop. For scaling, they would bring the two sides apart.

Although this concept creates a relationship between the physical and digital domains, it seemed counterintuitive to the naturalness of a system. This concept had the potential to break the smoothness of a presentation thus remained a concept. It did though address certain core design criteria, such as allowing iconic and metaphoric information conveyed by gestures to be used in manipulating design material. As was noticed in the research phase, participants were trying to manipulate parts of their sketches after selecting those areas. This

concept would allow that to actually make real time changes to their sketches, thus increasing the information being imparted.

Concept 2: Over Head Camera

- Over head camera detects hand gestures and allows manipulation of placed object
- Allows for scanning of material (Sketches especially, and possibly Models)
- Hand gestures and material are both visible to the audience

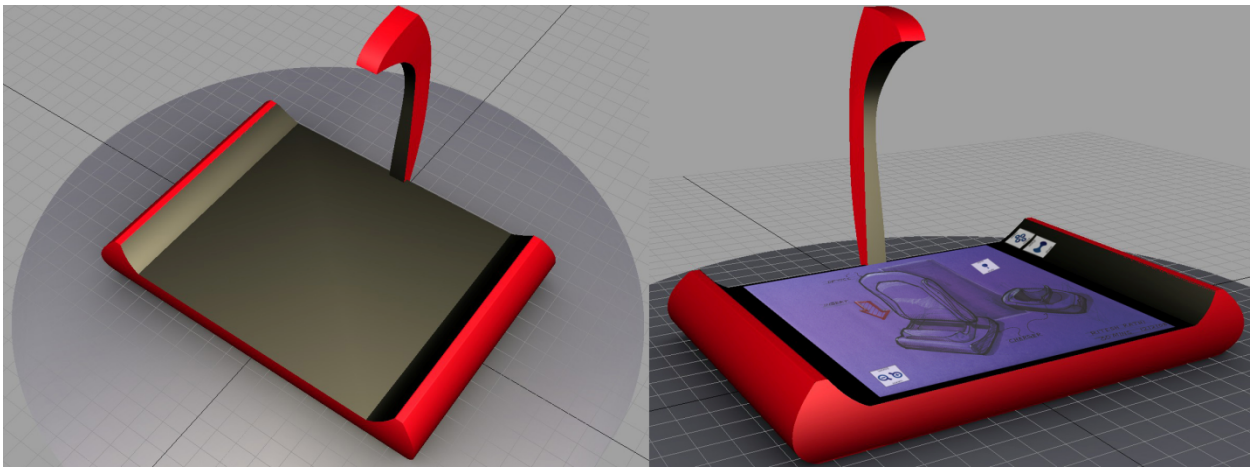


*Figure16: Concept 2- Over Head Camera*

This concept revisits an older method of presentations that used over head projectors. Presenters in this case would address their design concepts in real time by placing their hands under a camera to perform functions. Below them would be sketches they had made. The camera would capture the movements the hands would make over the sketches and then presented to the audience. This addressed the issue of gestures not being noticed by the audience. It also made the process of selecting specific areas of a sketch a lot easier as the

sketches were within the hands range of the presenter. They could also skip to the next page, select objects on their screen etc., in this concept.

Concept 3: Sketch Describer

- Allow hand gestures to *animate* sketches
- Incorporate descriptors on sketches, such as arrows and scale, which can be explained through hand gestures

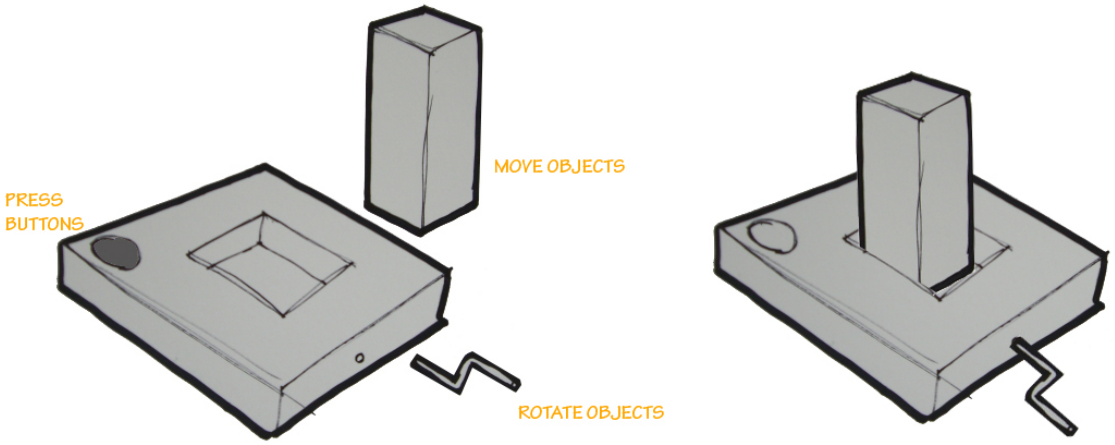



*Figure17: Concept 3- Sketch Describer*

This concept would facilitate the presentation of sketches by making them more robust and less rigid. Sketches would be manipulated by hand gestures and be better explained, then simply having arrows and notations on sketches. For instance, to rotate an object, the user would perform a gesture to rotate it. This real time manipulation of sketches would overcome the issue of having static sketches that required the need for gestures to explain the sketches in more detail.

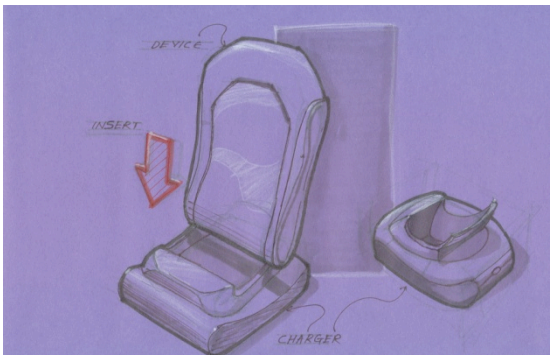



*Figure 18: Example of Sketch for Sketch Describer*
*An example of a sketch with arrows that depict direction of an object in a sketch and other notations.*

Concept 4: Proof of Concept Study

A concept derived from the above initial concepts was tested via a prototype, with 2 designers presenting their projects via sketches. In this concept, key features from the three design concepts were tested for their feasibility when being used by designers to communicate their thoughts on their projects. Two separate students were asked to present their sketches on an overhead projector.

On top of the projector a camera captured the sketches being presented. The presentation technique was similar to how they would have presented their concepts in an informal setting, except that the researcher asked the presenters to use the tangible interface that included individual physical objects. The physical objects stood for specific design attributes (derived from the results section and included scale, rotate, zoom etc.) and were placed on the overhead projectors working surface. There were two types of objects, one for

manipulation and the other for navigation. The manipulation objects were scale, rotate and shape, and the navigation objects were next/previous, zoom and move. The participants were asked to use them by placing them near their sketches, whenever they were taking about those attributes. Although the manipulation did not have an output, it did identify how comfortable the participants were when using such a system.

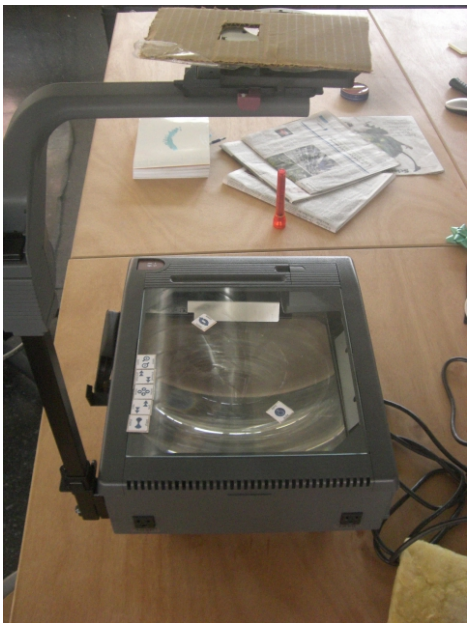


*Figure 19: Over Head Concept*

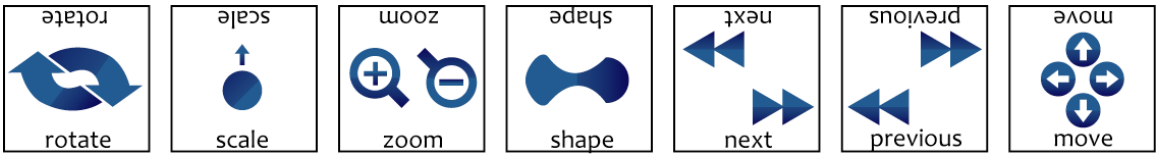



*Figure 20: Attributes of Physical Objects*

The details of the two experiments are listed below:

Experiment 1: In experiment 1, participants were asked to present their sketches, using the overhead projector concept. Participant was allowed to use a pencil as a prop. The pencil was used by the participant to select objects in their

sketches as well as point at attributes, as well as used to sketch over the sketches.

During the presentation, participants struggled to use the appropriate physical manipulation objects, but used the pencil consistently to select objects and manipulate the sketches they had already done. They did this by either drawing over their sketches or annotating their sketch with call outs and arrows. Participants used the information space well, by placing sketches next to each other to make comparisons. The comparisons were pointed out by using the pencil. The pencil acted as a focus point for their presentation and was even employed to make a shape (a 90 degree angle). A participant's free hand (i.e., the one not holding the pencil) was also used whenever the explanation needed two hands. Participants did not use the objects as it seemed that the pen was doing the work of the physical objects.

Experiment 2: In experiment 2 participants were not allowed to use a pencil, and struggled with the selection and identifying of attributes with their fingers. Participants used their fingers to point and select the specific areas of their sketches that they were talking about. Participants got used to the physical manipulation (e.g. shape and rotate) objects and utilized them during the presentation. The physical navigation objects were not used often. However, when they were used, they seemed forced. It was noted that although one participant would be able to start an interaction using the manipulation objects, he/she was unsure how to end it. This participant also used the information space

very well with the hands being brought in when they needed to explain their sketches. The hands did have a tendency to cover the sketches.

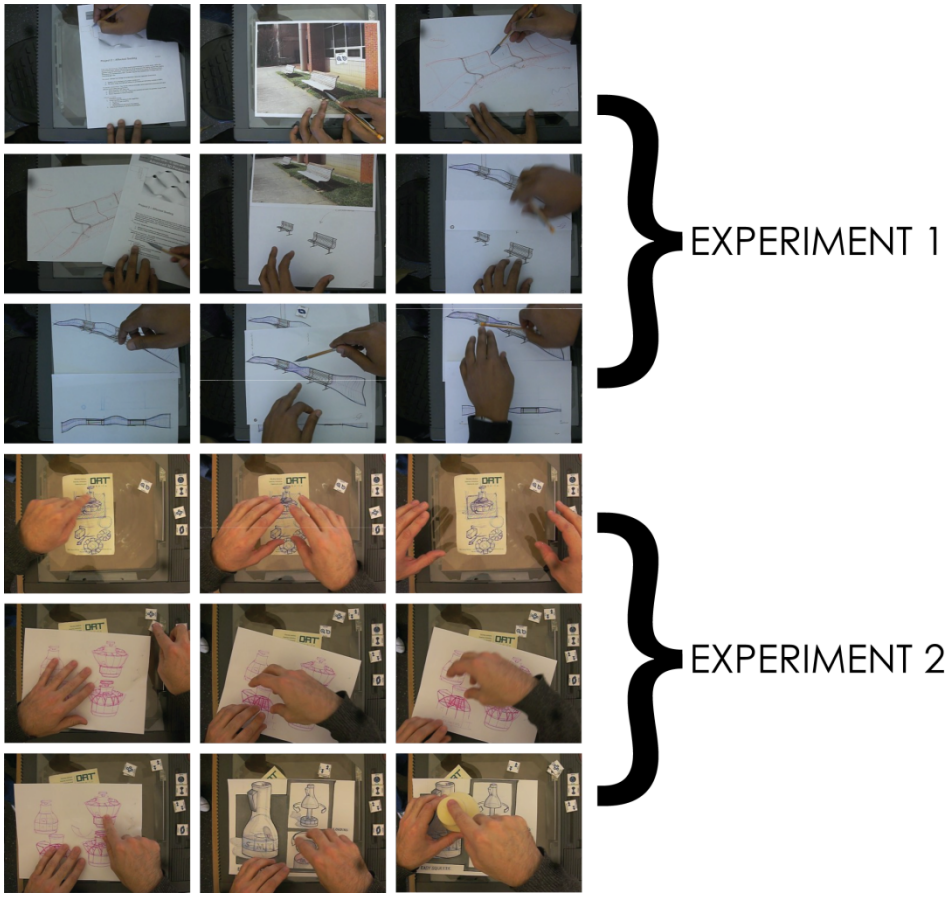



*Figure 21: Summary of Proof Of Concept*

Analysis of Concept 4

This concept revealed some very interesting observations. The participants seemed very comfortable presenting their sketches in this fashion. Conversations after the finished the test revealed how they enjoyed having their sketches in front of them while presenting.

The physical objects were a hindrance to the natural flow of the presentation, but the pencil in experiment 1 seemed natural. The form of the pencil that lets it

fit comfortably between fingers as well as the familiarity designers have with writing instruments might have been the reasons for this naturalness. During the tests, the presenters were referring to the manipulation objects, suggesting that they were appropriate for the presentation, but weren't used as they probably seemed unnatural. The navigation objects may have not been used as the sketches were physical. This might change if the sketches were being presented digitally. The presenters did go through many sketches and even referred to sketches they had already presented.

What was also interesting to note was how the gestures in this concept became front and center, instead of occurring on the side, (as was the case during the formal presentations in the Observation studies). Clearly, gestures were part of the main communication stream. With the camera placed right above the hands, the gestures being performed were clearly visible as well as informative. It was clear (especially with the pencil in experiment 1) what area of the sketch the presenters were referring to. Even when the gestures did not relate to manipulation or navigation they were helpful in highlighting the presenters focus (through beat gestures).

# CHAPTER 9

## FINAL SOLUTION

The analysis of concept 4 revealed how a solution that incorporated an over head camera could enhance design presentations, especially when sketches and other design materials are part of the presentation. The final solution builds on this concept with one key improvement. Instead of using the physical objects, the final solution uses a palette for selection of an attribute and a stylus for the manipulation and navigation. The solution also successfully addresses the design guidelines.

Gestures in the final solution are involved in the navigation of a presentation (e.g. moving to the next slide) and the manipulation of the material being presented (e.g. Sketches). During the literature review, it was discussed how simplifying the mediation required by users to perform tasks can improve the experience of using technology related products. Gestures can be one method for improving the experience of receiving and imparting information by enhancing the navigation and manipulation of the presentation.

Gestures, as the research phase realized, are performed to explain design attributes (e.g. Shape of an object), which is how they can aid in the design presentation process. The solution derives features from each of the design concepts presented in the previous chapter. The product is similar to an overhead camera (concept 2) with a workable surface that uses a stylus as well as gestures to manipulate and navigate a presentation. The content, especially

design sketches, can be manipulated (concept 3) using the stylus and hand gestures. The stylus also acts as a metaphor (concept 1) for the attributes a designer is trying to communicate. A palette, which provides easy selection of menu items, is also available.

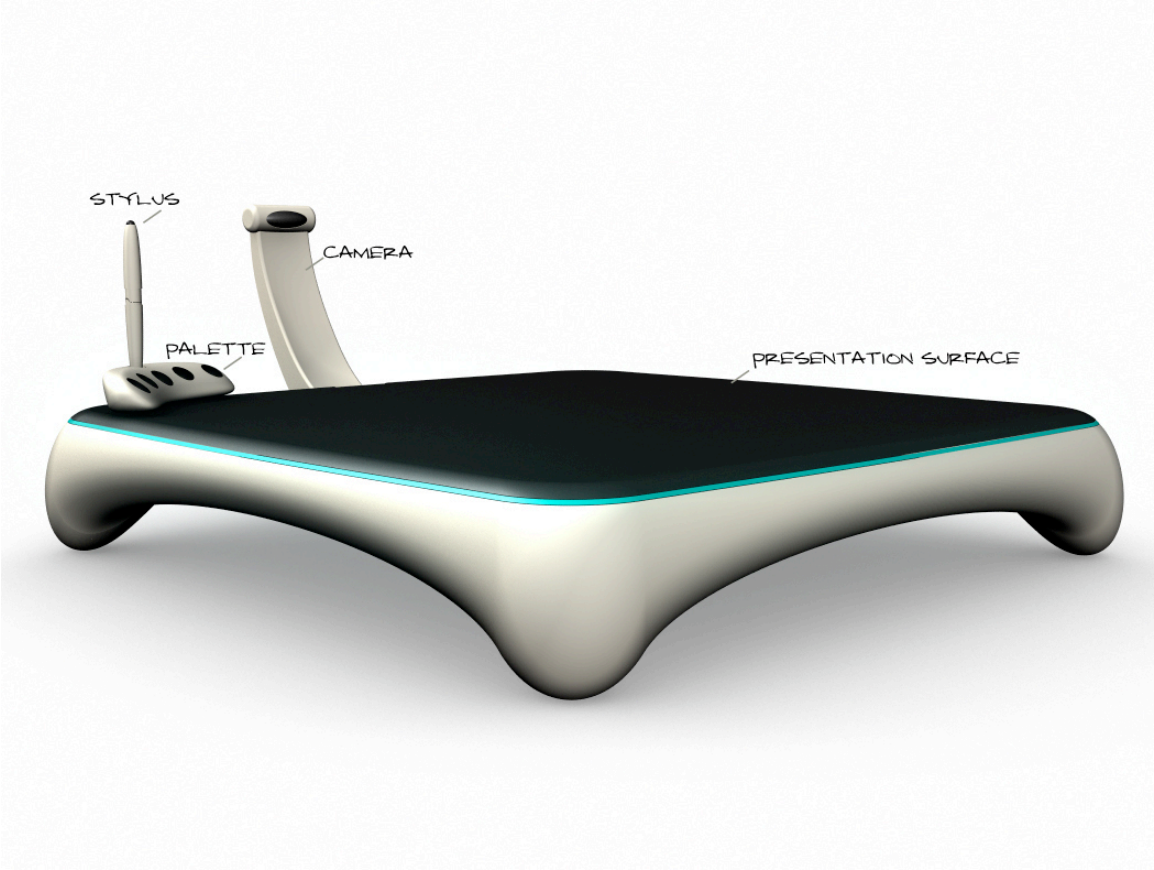



*Figure 22: Final Solution*

The final solution is explained through three steps: Setting Up, Manipulation and Navigation.

**Setting Up**

Waving the hands in front of the camera turns on the device. The camera can also be adjusted to show the hands in a clearer manner.


*Figure 23: Turning on and Adjusting*

Design material such as paper sketches can be directly scanned on the surface either during or prior to a presentation. This addresses the issue of easily and quickly incorporating design material into a presentation. Multiple sketches can be displayed on the screen at any time, allowing a user to compare sketches. The camera captures the hand movements the user is making while presenting and then displays those movements in the corner of the projected presentation making the gestures more visible to an audience.

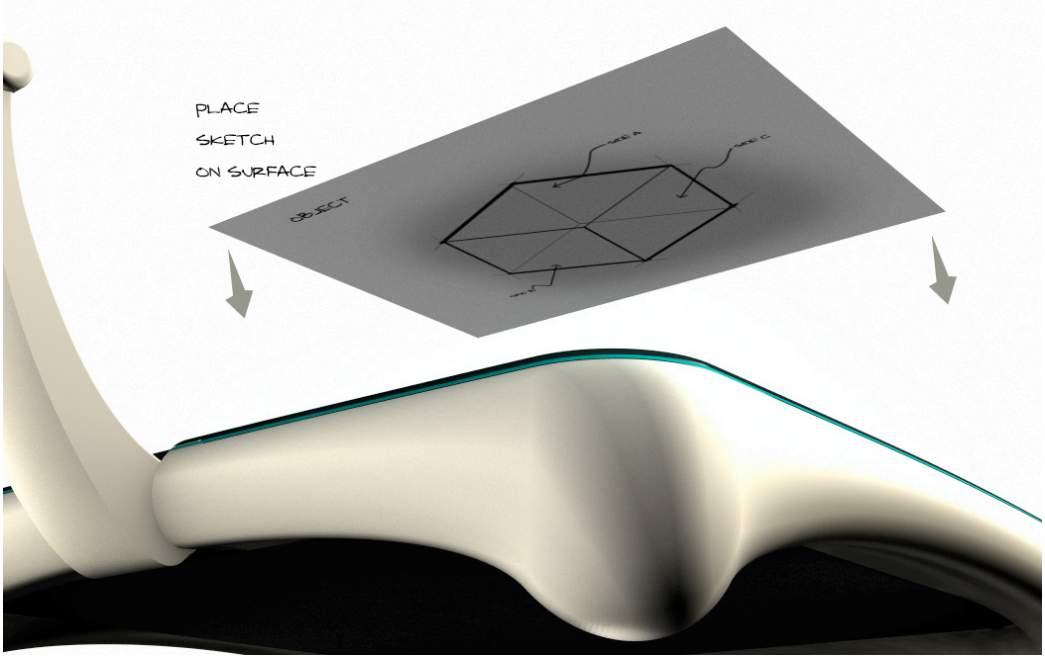



*Figure 24: Scan Sketches*

Images and presentations can also be preloaded through a USB drive. This provides flexibility in adding design material into a presentation.

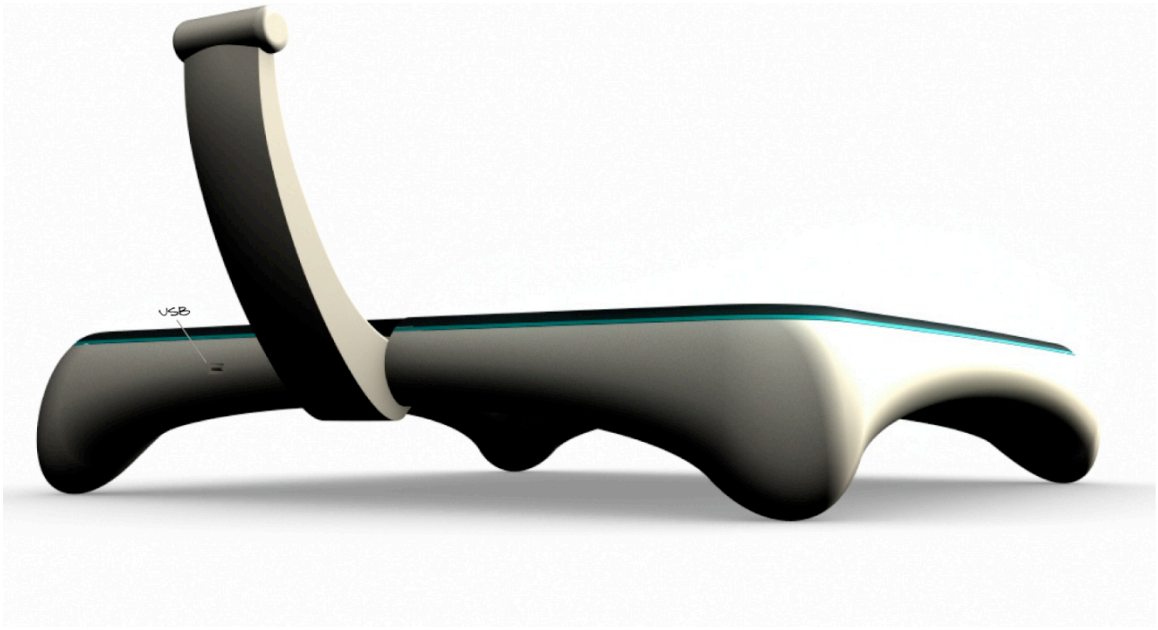



*Figure 25: USB Slot*

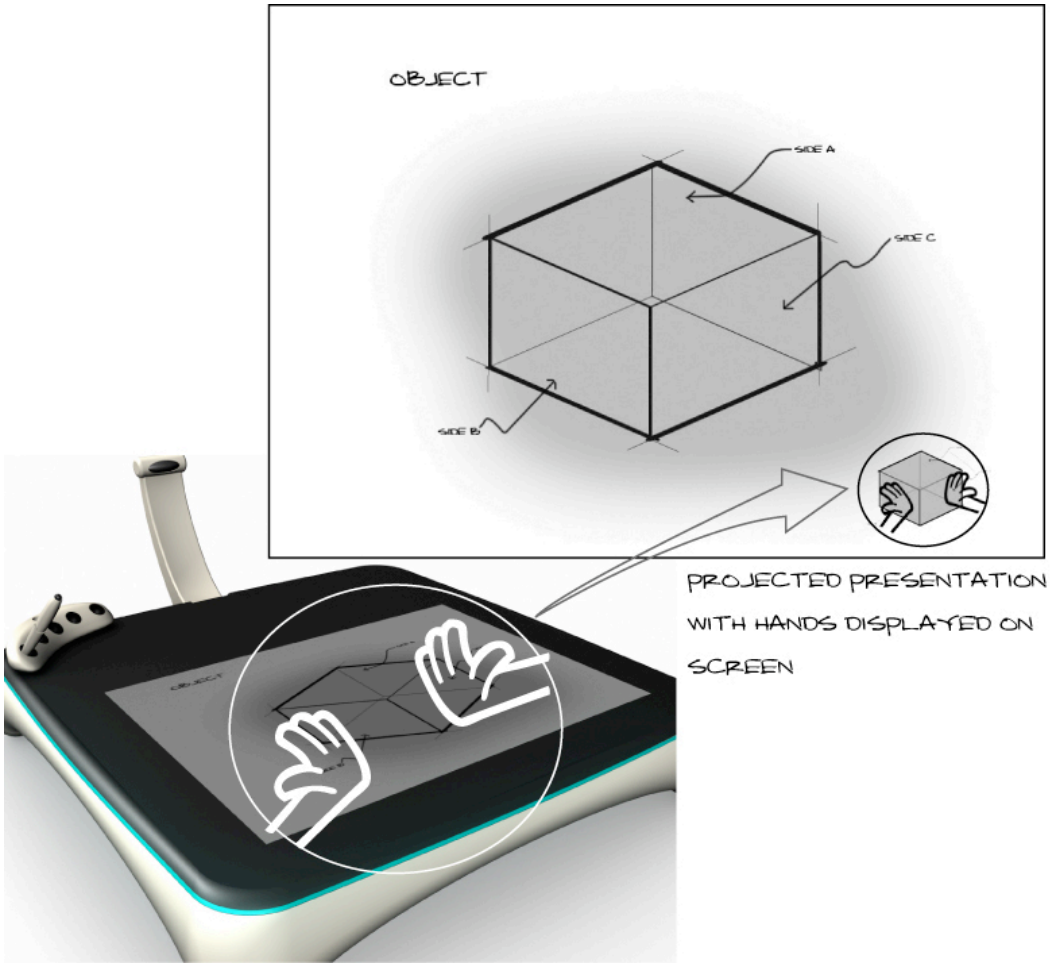



*Figure 26: Projection of gestures on screen*

Similar to an artist's palette, into which an artist can dip his brush, this palette is the part of the device the user can use to select functions and attributes by dipping the stylus. It can be placed in any area around the device to overcome issues of it intruding the information space. The palette is also important in selecting and deselecting attributes. The standard attributes in the palette are a pen tool, a marker, a selection (or de-selection) tool, a shape tool and a selection marquee tool.


*Figure 27: Palette*

**Navigation**

The solution makes it easy for the user to navigate through the presentation. The stylus pen acts as a tool to sift through a presentation. Accelerometers built into the stylus allow for this to happen. With the stylus, the user can go back or forward (if it was preloaded) in the presentation.

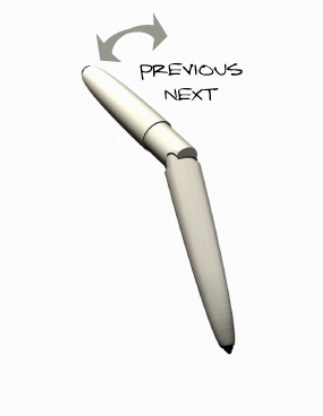



*Figure 28: Stylus Previous-Next*

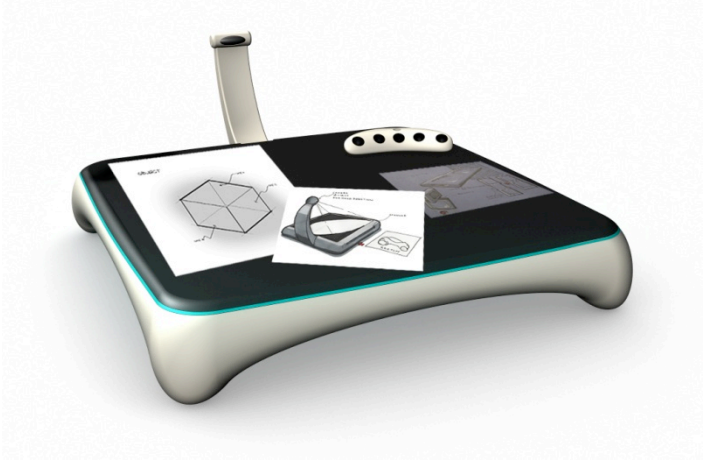


*Figure 29: Multiple images on the surface*

By holding down the stylus on the working surface, all the images in the presentation are shown on the screen, making it easy to select images and make comparisons between two sketches.

Other navigation features include zooming in/out of an area by using the stylus (figure 41).

**Manipulation**

Probably the most striking feature of this solution is its ability to allow the manipulation of the digital medium in real time. The device has the ability to shape sketches as well as annotate on them whilst presenting.

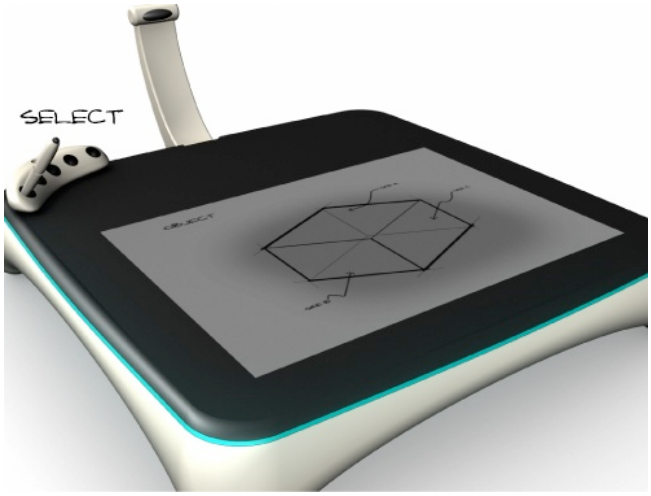



*Figure 30: Selecting the shape tool*

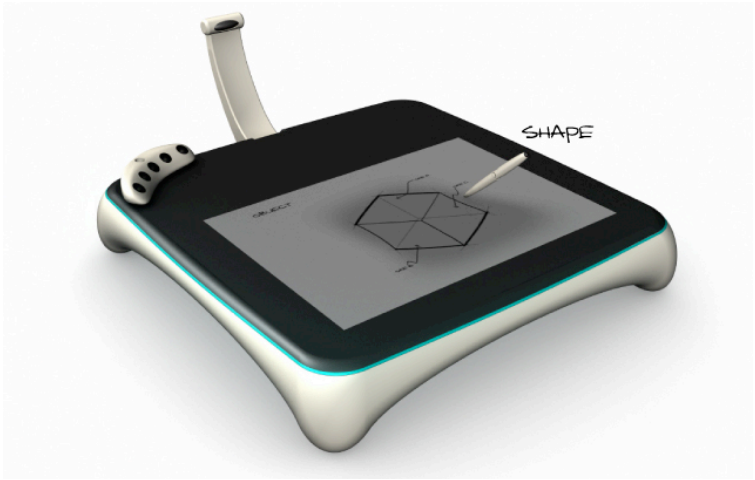



*Figure 31: Shaping the sketch*

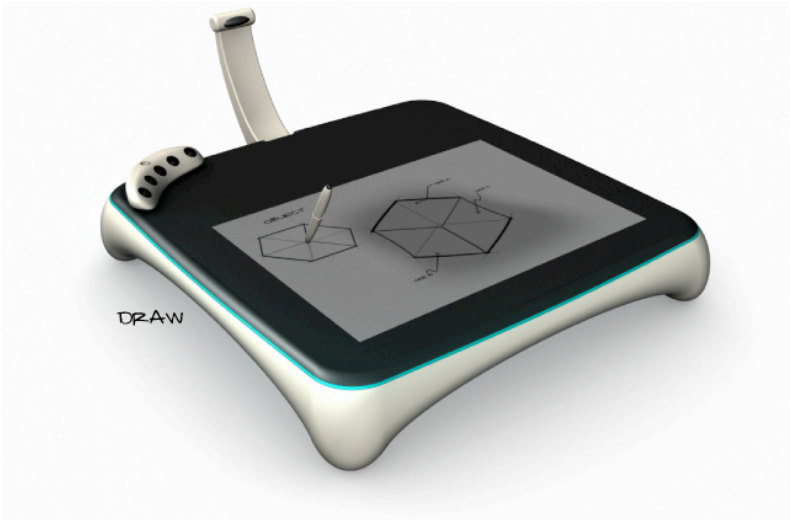



*Figure 32: Drawing-Annotating on a sketch*

The stylus is used to select and manipulate the sketches. The stylus is versatile and acts as a metaphor for the attributes a user is trying to communicate. With the stylus a user can select the area in the sketch they want to manipulate, zoom in and out of that area as well as rotate the selected area. The select area of the stylus acts as a shaper, and when used can transform that part of the sketch. The selection tool in the palette lets the presenter choose which area of a sketch they would like to manipulate.

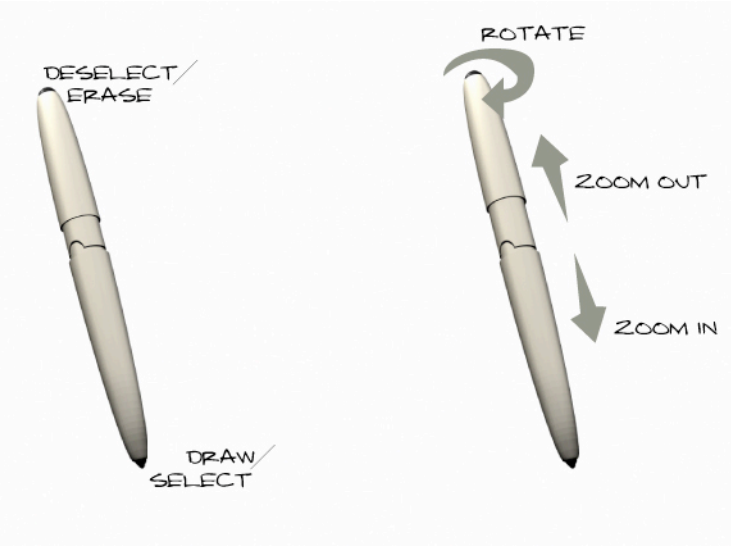



*Figure 33: Stylus for Manipulation*

## CONCLUSION

This study revealed the importance of hand gestures during design presentations and addressed the issue of incorporating them (with the help of technology) into a solution that impacts the manner in which human communication, especially in a group occurs. The issues of understanding how gestures are used, what they communicate in co-creative design communications and how that understanding can be applied towards a solution were addressed through the two-phase design of this study: the research phase and the design phase. The research phase of this study recognized the importance of gestures in design communication while the design phase applied that understanding towards a solution that augments the presentation of design materials. The final solution with the stylus and palette acting as metaphors for design attributes, become extensions of the human. Also, the use of the camera capturing and presenting gestures being performed to an audience, as well as the manipulation of the design material in real time, address the issue of using gestures within an interface.

Although the solution successfully incorporates gestures and the meaning of gestures into a solution, the researcher recommends a testing of the solution as a working prototype. Testing a working prototype would reveal gaps and validations in the conceptualization of the solution. Studies on the form and functionality of the stylus and palette are also recommended and a further analysis into the finer details of the interface. Issues with the interface will only surface when tested in a real setting.

Lastly, it is recommended to explore how the final solution can facilitate design

creation rather than just design presentations as well. Having this done, the features of the final solution would be further enhanced, and it has the potential of becoming a true mechanism for design development.

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## APPENDIX A

## IRB CERTIFICATION

The following chapter describes the process of IRB approval received for the ethnographic studies, validation experiments and design surveys.

The studies were approved by the IRB (Internal review board) for following the protocols of confidentially, recruitment procedures and the consideration of the rights of the participants.

Protocol Description:

The goal of this study is to understand what hand gestures are produced in the different phases when designing a product (e.g. Cellphone). The project proposes to conduct observational studies and surveys with human subjects, more specifically students at College of Architecture of the Georgia Institute of Technology. It is intended to observe industrial designers producing hand gestures in different classroom environments.

The data will be collected via video cameras. All the visual data collected will be coded and analyzed (with Observer software by Noldus) in order to produce a taxonomy of hand gestures produced in the context of this study. The gestures will be 'mapped' with specific functions that may be useful in design phases. Gestures identified in the observational phase will be used in survey studies. Additional industrial designers will be given a survey to identify meaning of

produced gestures. The goal is to validate observational findings with user data evaluation of the meanings attached to gesture production.

The following email was sent to recruit potential participants

**IRB protocol Ritesh Rathi**
**Recruitment Emails**
**Aug. 27, 2008**
The following are sample emails that will be sent to potential participants as a recruitment tool.
**Email for Research Phase:**
Dear Design Students,
For the purpose of my graduate thesis project, I would be extremely grateful if you would allow me to observe group discussions that you may be having for your studio classes. Please let me know when and where you will be having such meetings.
During my observation I will be recording your behavior, and specifically focusing on the manner in which you use your hands for communication purposes. The aim of my research is to understand how gestures/ hands are used during design discussions.

During the research I will not directly interact with you or your group. I will be recording the meetings using video and still cameras and taking notes with a pen and pad.
If you have any questions about my research, please let me know. If you are willing to help me during this phase, please have all your group members sign the attached consent form. I will also provide the forms prior to your meeting.

The data that will be collected will not be used for any commercial purposes, and is entirely for academic purposes. No personal information (e.g. Names) will be used during the study. The data will be presented for the partial completion of my masters thesis and MID Degree.
Thanks for your expected help.
Sincerely,
Ritesh Rathi

Besides the IRB Proposal, participants were also handed a consent form

**FORMAT FOR CONSENT FORM**
**ADULT SUBJECTS (18 YEARS OLD AND OLDER)**

**Georgia Institute of Technology**
**Project Title:** Gestures in Design: How gestures facilitate the design process.
**Investigators:** *Ritesh Rathi, Claudia Winegarden*
**Consent title:** Version 2. October 8 2008
**Research Consent Form**

**Purpose:**
**The purpose of this study is:**
- *The purpose of this study is to understand how industrial designers use gestures during design meetings.*
- *As gesture based technology is becoming a prominent interface function, it has become relevant to understand what gestures are appropriate for specific functions.*
- *The research conducted will occur in two phases. Each phase tries to understand the natural use of gestures.*

**Procedures:**
**If you decide to be in this study, your part will involve:**
- *The research conducted is strictly observational. The researchers will not directly interact with any of the participants as the study focuses on understanding the natural environment where designers practice design meetings.*
- *The researchers will be using video cameras and microphones for recording the meetings. The researcher will also be taking notes with a pen and paper. Both Audio and Visual data is required as the researchers are attempting to understand how gestures are used during communication.*

**Risks/Discomforts**
**The following risks/discomforts may occur as a result of your participation in this study:**
- *The research conducted has very low risk for the participants. The risks involved are no greater than those involved in daily activities such as conversing with colleagues and other students.*

**Benefits**
**The following benefits to you are possible as a result of being in this study:**
- *You are not likely to benefit in any way from joining this study. But we hope that others, with the research conducted here, will benefit the design and technological communities from what we find in doing this study.*




**Compensation to You**
- *No compensation will be provided during this research. The role of the researcher is to not be directly involved with the participants.*
- *As no extra time and effort on behalf of the participant is required, monetary compensation will not be offered.*

**Confidentiality**

**The following procedures will be followed to keep your personal information confidential in this study: The data that is collected about you will be kept private to the extent allowed by law. To protect your privacy, your records will be kept under a code number rather than by name. Your records will be kept in locked files and only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published.**

- *Any quotations used during the recording period will not be attributed directly to the person making the quote.*
- *The digital data (video and audio) collected during the research will only be available to the researchers and will not be shared with any person outside the research program.*
- *The data will be saved on secure pasaword protected private computers.*
- *The data will only be stored for the duration of the thesis, i.e. until Dec. 14 2008, after which they will be promptly deleted.*
- *At any time when the data is presented, no personal information will be divulged.*
- *The research conducted is strictly for academic purposes.*
- *Data from the first phase will not be used for the next phase directly, i.e., only the analysis will be used and none of the actual data collected.*

**To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB may review study records. The Office of Human Research Protections may also look at study records.**

**Costs to You**
The research poses no financial or physical costs to the participants. The research will be conducted during the meetings the participants have already designated as a meeting time.

**In Case of Injury/Harm**




If you are injured as a result of being in this study, please contact Dr. Abir Mullick at telephone 404.894.4874. Neither the Principal Investigator nor Georgia Institute of Technology have made provision for payment of costs associated with any injury resulting form participation in this study.

**Subject Rights**

- Your participation in this study is voluntary. You do not have to be in this study if you don't want to be.
- You have the right to change your mind and leave the study at any time without giving any reason, and without penalty.
- Any new information that may make you change your mind about being in this study will be given to you.
- You will be given a copy of this consent form to keep.
- You do not waive any of your legal rights by signing this consent form.

**Questions about the Study or Your Rights as a Research Subject**

- If you have any questions about the study, you may contact Dr. Claudia Winegarden at telephone 404.894.4874 or Ritesh Rathi at telephone 912 224 2143
- If you have any questions about your rights as a research subject, you may contact Ms. Melanie Clark, Georgia Institute of Technology at (404) 894-6942.

**If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to be a volunteer in this study.**

_____
**Subject Name**

**Subject Signature** **Date**

**Signature of Person Obtaining Consent** **Date**

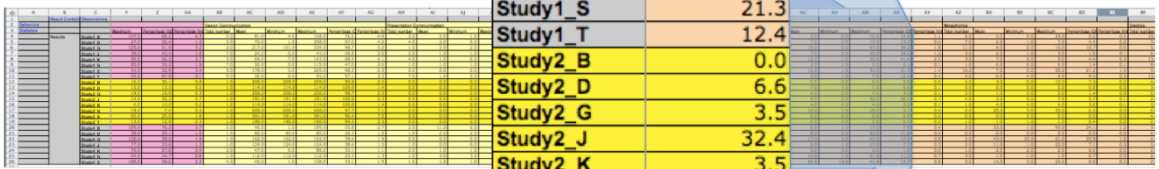



*Figure 34: Adult Consent Form*

## APPENDIX B

## DATA COLLECTION

*Table 11: Example of Concrete Data*

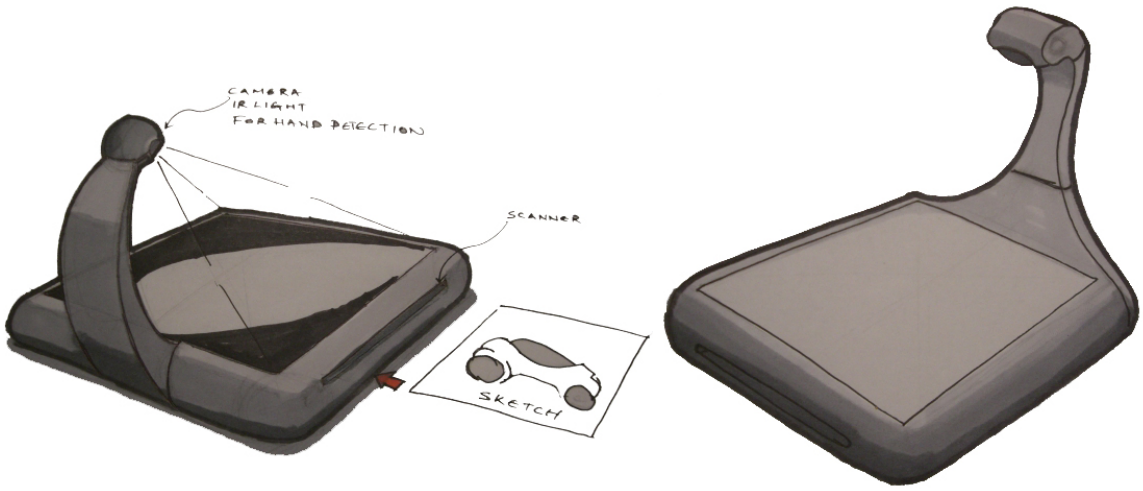


| | Percentage (Observation) |
|---|---|
| Study1_B | 16.8 |
| Study1_D | 13.5 |
| Study1_G | 34.2 |
| Study1_J | 28.6 |
| Study1_K | 41.4 |
| Study1_N | 2.1 |
| Study1_S | 21.3 |
| Study1_T | 12.4 |
| Study2_B | 0.0 |
| Study2_D | 6.6 |
| Study2_G | 3.5 |
| Study2_J | 32.4 |
| Study2_K | 3.5 |
| Study2_N | 5.1 |
| Study2_S | 0.0 |
| Study2_T | 6.5 |
| Study4_B | 7.9 |
| Study4_D | 11.8 |
| Study4_G | 17.0 |
| Study4_J | 7.7 |
| Study4_K | 1.2 |
| Study4_N | 11.3 |
| Study4_S | 14.7 |

## APPENDIX C

## DESIGN CONCEPTS

Concept 2 (Over Head Camera)



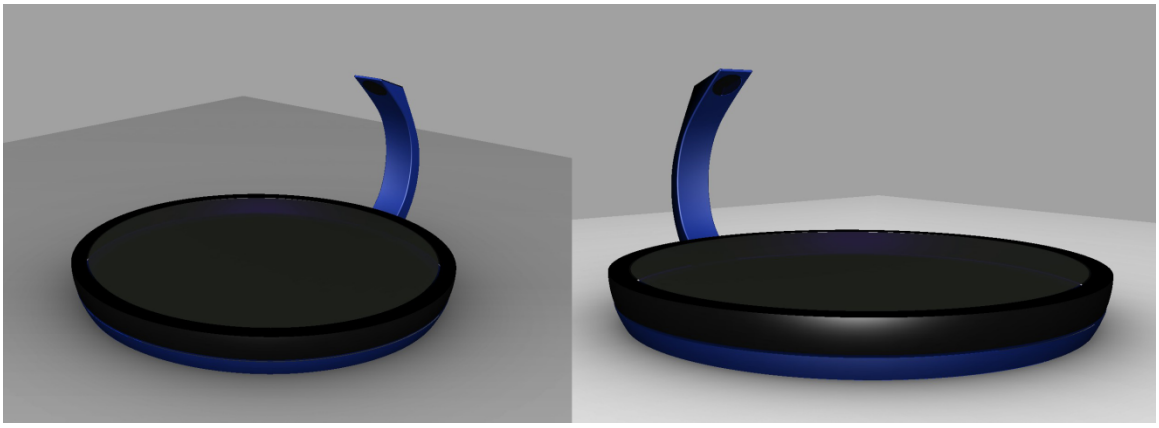



*Figure 35: Concept 4 Development*

Concept 4 (Glove) Guidelines

- Control of presentations using a glove built in with accelerometers and Bluetooth.
- Allow for freedom of movement by hands
- One Size fits all as well as possible

This concept involved a user wearing a glove on their hands that had built in accelerometers that would detect any movement of the hands. Thisconcept seems the most obvious solution for incorporating gestures, but would again infiltrate the smoothness of hand gestures as the glove would have difficulty distinguishing between certain gestures. Our validation experiments showed that although gestures were easily understood, there was too much similarity between certain similar features (e.g. next and layers)

SKETCHES FOR FINAL SOLUTION

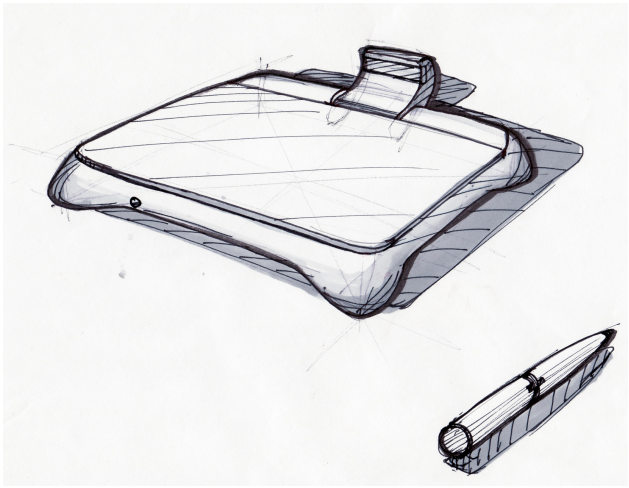


*Figure 36: Sketch for Final (1)*

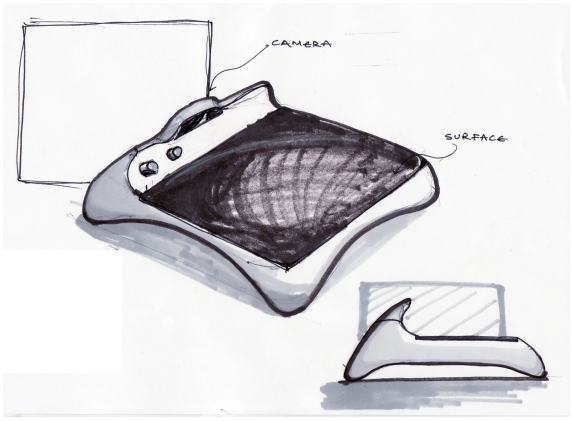



*Figure 37: Sketch for Final (2)*